ASSESSMENT REPORT

Department of Defense
Air Traffic Control and Airspace Management Systems

Prepared for:

Headquarters, Electronic Systems Division
United States Air Force Systems Command
Hanscom Air Force Base
Massachusetts 01731
Attn: Captain Guy St. Sauveur

Prepared by:

Engineering and Economics Research, Inc.
1801 Alexander Bell Drive, Suite 200
Reston, VA 22091

Contract No. F19628-87-C-0172

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This report assesses the inter-service and intra-agency compatibility of ATC and airspace management systems for a broad spectrum of military applications. Current DoD systems are evaluated by type of system (i.e., fixed or tactical), application (i.e., radar, position/navigation, communications, etc.), and branch of military service. The potential near-term impacts of incompatible and non-interoperable systems on the Air Force are described in terms of safety and operational effectiveness and probable impacts on service-specific mission accomplishments. The report briefly describes but does not assess evolving concepts in tactical command and control systems that are not directly related to ATC. These systems will be discussed in greater detail in subsequent analyses. Systems such as military long-range phased-array radar are excluded from the present discussion, but may be evaluated in later reports as potential ATC supporting systems.

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1.0 INTRODUCTION

As mandated in the Federal Aviation Act of 1958, the Federal Aviation Administration (FAA) is responsible for establishing and maintaining a common air navigation and air traffic control system for both civil and military aircraft. The Act also stipulates that the FAA shall operate the common system in full consideration of the requirements for national defense. As an outgrowth of these requirements, the military is responsible for providing some of the nation's air traffic control (ATC) services, which serves to maintain the military's ATC proficiency as a contingency need and readiness posture.

The FAA published the National Airspace System (NAS) Plan in 1981 to establish the schedule for system modernization into the 21st century. Implementation of the NAS Plan focused attention on the Department of Defense (DoD) role as a user and provider of NAS services. To perform its role effectively, DoD recognized that future military ATC, air navigation, and airspace management system components must interoperate and/or interface with FAA systems modernized under the NAS Plan. Interoperability involves a greater degree of integration than compatibility, the technical capability of exchanging information. Interoperable systems are compatible systems which are capable of directly integrating and utilizing the information exchanged.

While a substantial amount of effort has been expended on the near-term integration of military and civil systems, the organizational structures that have been established to achieve the interface are only now beginning to address transcentury planning requirements beyond the scope of the NAS Plan. The long-term inter-service and intra-agency interface needs for ATC and airspace management systems remain to be studied in-depth. For example, long-range planning has not addressed the interface between survivable military and civil aviation command and control systems as well as battle management command and control systems in a conventional wartime environment. Furthermore, a method has not been defined for achieving DoD interoperability for deployable systems or for establishing related national and international interface requirements. Considerable study will be required to assess the interoperability issues inherent to existing and future concepts for advanced domestic and/or deployable military ATC systems.

1.1 Background

To establish an approach for future ATC systems development, military planners must address two distinct, but related operational aspects associated with NAS interfaces and aviation in general. First, as a major user of the NAS for both tactical readiness and self-logistics support purposes, military aviation must operate in the NAS in consonance with civil users in a concurrent or separately sanitized environment, which involves the use of common or interoperable air navigation and communications equipment and avionics. Second, as a co-provider of NAS services, military ATC and airspace management systems must interface with civil systems to an extent that assures the user of a transparency of ATC service origin and no derogation of services. The first issue, the military interface with the NAS as a major user, is not a primary area of research in this assessment. However, the issue is recognized for its importance and inseparable relationship with civil/military ATC and airspace management systems interface.

While considerable research is being conducted with respect to the interfacing of military and civil systems in the evolving "end-state" NAS configuration, more information is needed on the operational inefficiencies of incompatible and/or non-interoperable systems within the context of inter-service air traffic control and airspace management. Traditionally, each military service has managed their individual systems independently, which has prevented them from evolving in balanced recognition of both the individual service and the collective DoD roles in supporting peace and wartime military flight operations.

1.2 Objective

The purpose of this assessment is to provide an understanding of the potential problems associated with the lack of interoperability and compatibility between existing military ATC systems, including those currently in procurement, and the civil systems with which they must interface. This report and subsequent analyses will establish a planning baseline for current and developing system components, assess the impacts of incompatible interfaces, and outline the potential post-2000 military ATC and airspace management system requirements and operations concepts needed for the long-range planning of DoD ATC and airspace systems in the 21st Century. The overall objective is to identify the preliminary system level requirements and operations concepts necessary to support the development of future command, control, and communications (C^3) systems that include provisions for ATC.

This report does not address, in depth, the FAA system into which military ATC must interface, in order to focus on military ATC systems. Other previously conducted and well-received studies that have examined the overall system in detail include the February 1987 Hart Report entitled "Requirements for Air Traffic Control Interoperability Between FAA and DoD" prepared by the MITRE Corporation, as well as the July 1986 staff study "Qualitative Assessment of Potential Impacts of Lack of Modernization of the Department of Defense Air Traffic Control System on Expected FAA Benefits and Costs of the NAS Plan," prepared by the Martin Marietta Corporation. The intent of this report is, again, to establish a baseline for the development of an operations concept for future military ATC and related C^3 systems.

1.3 Scope

This report assesses the inter-service and intra-agency compatibility of ATC and airspace management systems for a broad spectrum of military applications. Current DoD systems are evaluated by type of system (i.e., fixed or tactical), application (i.e., radar, position/navigation, communications, etc.), and branch of military service. The potential near-term impacts of incompatible and non-interoperable systems on the Air Force are described in terms of safety and operational effectiveness and probable impacts on service-specific mission accomplishments. The report briefly describes but does not assess evolving concepts in tactical (battlefield) command and control systems that are not directly related to ATC. These systems will be discussed in greater detail in subsequent analyses. Systems such as military long-range phased-array radar (e.g., the Air Force's Over-The-Horizon radar system) are excluded from the present discussion, but may be evaluated in later reports as potential ATC supporting systems. Finally, although individual system capabilities that protect against hostile electronic countermeasures (ECM), anti-radiation missiles (ARM), electro-magnetic pulse (EMP) generation, and chemical-biological weapons are

crucial to the wartime accomplishment of ATC responsibilities, they are not especially germane to this assessment. These capabilities are only addressed, therefore, with respect to their influence on service planning for replacement systems. All of the information presented in this report is unclassified and was freely provided by military, federal, and commercial sources.

1.4 Document Organization

The remainder of this document is organized in the following manner. Section 2 consists of the assessment report, which is divided into two subsections. The first subsection provides an overview description and assessment of military fixed-base and tactical ATC and airspace systems. The second subsection discusses the interoperability or compatibility of DoD systems. Section 3 presents the findings and results of the analysis.

2.0 TECHNICAL REPORT

The research for this report began with the development of a database of descriptive information on current and planned major military ATC and airspace management system components. The systems information was compiled in sufficient detail to assess the degree of functional inter-service compatibility and interoperability. This information provided a baseline upon which to assess the consequences of their use on Air Force systems and missions. The assessment evaluated the impacts of incompatible and non-interoperable systems in terms of safety, ATC operational effectiveness, and airspace management as it relates to mission accomplishment. A derogation of safety, from the standpoint of aircraft collision avoidance, is probable where service specific systems are operating in adjacent or overlapping airspace. If necessary flight restrictions are imposed to ensure safe flight operations, there is the potential problem of reduced ATC effectiveness. Service specific missions involving air superiority, close air support, reconnaissance, logistics, etc., could be affected by situations of derogated safety and/or operational effectiveness.

2.1 Military Systems Assessment

In addition to the systems evaluation, the analysis leading to this assessment included reviewing major ATC components at most military installations within the NAS to determine the status and composition of the DoD architecture. On December 14, 1988, the DoD and the FAA implemented a Memorandum of Agreement on Radar Approach Control in the National Airspace System. The purpose of the memorandum of agreement was to "...identify locations of approach control authority for military and FAA radar approach controls in the...(NAS) and their relationships to Area Control Facilities (ACF)." Interagency Agreement A to the memorandum established the DoD-FAA ATC architecture for the NAS (Appendix D). The memorandum is considered in this assessment due to the importance of the military ATC facilities identified in the interagency agreement. Table 1 lists the facilities and key equipment components.

2.1.1 Fixed Base Systems

2.1.1.1 Surveillance Systems

The national surveillance network is a composite of FAA and military long-range surveillance, airport surveillance, and beacon only radar systems. Long-range coverage is provided by FAA Air Route Surveillance Radars (ARSR), the majority of which are of the ARSR-3 type. The ARSR-3 is a coherent L-Band radar that provides horizontal coverage of 200 nautical miles (NM) and vertical coverage of up to 100,000 feet elevation from the radar site. It is used in conjunction with a beacon interrogator system to maintain long-range surveillance of controlled airspace for en route ATC. The FAA radars are supplemented by the Joint Surveillance System (JSS), a system of long-range facilities operated by the FAA and the Air Force to accomplish both ATC and national defense functions. The Air Force is converting the 1950 vintage FPN-90 and the FPN-93A radars at JSS installations with new FPS-117 solid-state, L-band, three-dimensional long-range radars. The operational FPS-117 systems in Alaska are integrated into the FAA en route system. Beginning in 1990, older FAA and JSS long-range radars will be replaced by both the FPS-117 and the ARSR-4, another three-dimensional, long-range, primary radar with height-finder and a Mode Select (Mode S) Sensor

TABLE 2-1 - DoD Air Traffic Control Facility Listing*

Category of Facility Facility		ATC EQUIPMENT ASR	PAR	SSR
Stand-Alone Approach Controls Facilities:				
Army	- Ft Campbell, KY	GPN-20	FPN-61	TPX42(V)10
	- Ft Hood, TX	ASR-8	FPN-40	ARTS II
	- Ft Rucker, AL	ASR-5	FPN-40	ARTS IIIA
	- Ft Drum, NY	(TBA)	(TBA)	(TBA)
Navy	- NAS Adak, AK	GPN-27	FPN-63	TPX42(V)5
	- NAS Bermuda	GPN-27	FPN-63	TPX42(V)5
	- NAS Fallon, NV	GPN-27	FPN-63	TPX42(V)10
	- NAS Lemoore, CA	GPN-27	FPN 63	TPX42(V)10
	- NAS Key West, FL	GPN-27	FPN-63	TPX42(V)10
	- NAS Oceana, VA	GPN-27	FPN-63	TPX42(V)10
	- NAS Patuxent River, MD	GPN-27	FPN-63	TPX42(V)10
	- NAS Whidbey Island, WA	GPN-27	FPN-63	TPX42(V)10
	- NAVSTA Roosevelt Roads, PR	GPN-27	FPN-63	TPX42(V)5
USAF	- Castle AFB, CA	GPN-20	FPN-62	TPX42(V)10
	- Columbus AFB, MS	GPN-20	- ILS -	TPX42(V)10
	- Cannon AFB, NM	GPN-20	FPN-62	TPX42(V)10
	- Edwards AFB, CA (FAA)	ASR-7	- ILS -	M-DARC
	- Ellsworth AFB, SD	GPN-20	FPN-62	TPX42(V)10
	- England AFB, LA	GPN-20	FPN-62	TPX42(V)10
	- Galena AFS, AK **	GPN-20	FPN-62	TPX42(V)5
	- Holloman AFB, NM	GPN-20	FPN-62	TPX42(V)10
	- Laughlin AFB, TX	GPN-12	- ILS -	TPX42(V)10
	- Luke AFB, AZ	GPN-12	FPN-62	TPX42(V)10
	- King Salmon AFS, AK **	GPN-20	FPN-62	TPX42(V)5
	- Moody AFB, GA	GPN-12	FPN-62	TPX42(V)10
	- Mountain Home AFB, ID	GPN-20	FPN-62	TPX42(V)10
	- Myrtle Beach AFB, SC	GPN-12	FPN-62	TPX42(V)10
	- Nellis AFB, NV	GPN-25	GPN-22	EARTS/TPX42
	- Seymour-Johnson AFB, NC	GPN-12	FPN-16A	TPX42(V)10
	- Shaw AFB, SC	GPN-20	FPN-62	TPX42(V)10
	- Shemya AFS, AK	GPN-20	FPN-62	TPX42(V)5
	- Vance AFB, OK	GPN-20	- ILS -	TPX42(V)10
	- Vandenberg AFB, CA	GPN-12	- ILS -	TPX42(V)10
USMC	- MCAS Kaneone Bay, HI	GPN-27	FPN-63	TPX42(V)5
	- MCAS Beaufort, SC	GPN-27	FPN-63	TPX42(V)10
DoD Consolidated Radar Facilities (CRF):				
Sheppard CRF, with ATC responsibility for:				
	Altus AFB, OK	GPN-20	FPN-62	TPX42(V)10
	Ft Sill, OK	ASR-8	FPN-40	ARTS II
	Sheppard AFB, TX	ASR-20	FPN-62	TPX42(V)10
NAS Corpus Christi CRF, with ATC responsibility for:				
	Corpus Christi, TX			
	NAS Chase, TX	GPN-27	FPN-63	TPX42(V)10
	NAS Corpus Christi, TX	GPN-27	FPN-63	TPX42(V)5
	NAS Kingsville, TX	GPN-27	FPN-63	TPX42(V)10
NAS Pensacola ACF, with ATC responsibility for:				
	Eglin AFB, FL (CRF)	GPN-12	- ILS -	TPX42(V)10
	Gulfport, MS			
	Mobile, AL			
	NAS Pensacola, FL	GPN-27	FPN-63	TPX42(V)10
	Ft Rucker, AL	ASR-5	FPN-40	ARTS IIIA
	Tyndall AFB, FL	GPN-20	FPN-62	TPX42(V)10
Yuma CRF, with ATC responsibility for:				
	NAF El Centro, CA	(Operated by Los Angeles ARTCC)		
	MCAS Yuma, AZ	GPN-27	FPN-63	TPX42(V)10
Cherry Point CRF, with ATC responsibility for:				
	MCAS Cherry Point, NC	GPN-27	FPN-63	TPX42(V)10
	MCAS New River, NC	GPN-27	FPN-63	TPX42(V)5

NOTE: Above listing excludes DoD ATC facilities that will be transferred to the FAA and FAA Approach Controls that will be transferred to DoD. See facility listing at Appendix D.

* Approach control facilities identified in the Dec 20, 1988 Interagency Agreement A of the DoD-FAA Memorandum of Agreement on Radar Approach Controls in the NAS.

** Facility status pending results of regional DoD studies.

or ATC Beacon Integrator interface. Long-range coverage in the NAS will be provided by ARSR-3, ARSR-4, and FPS-117 systems by the mid-1990s.

2.1.1.1.1 Primary Radar Systems

The NAS coverage achieved by the long-range facilities is complemented by airport surveillance radars (ASR). ASR radar normally provides coverage to 60 NM. Although there are several types of surveillance radars in the DoD inventory, the two most common ASR systems used in fixed base approach control applications are the ASR-7 and the ASR-8.

The Air Force version of the ASR-7, the GPN-12, is a solid-state, dual-channel radar system that is compatible with beacon radar, microwave link equipment or landlines, video mapping equipment, and radar terminal display systems. The system, which uses a magnitron transmitter, is employed at 21 Air Force installations in the NAS and at Marine Corps Air Station (MCAS) Point Mugu, California. The GPN-12 incorporates 1960s technology, however, and has been difficult to maintain due to the non-availability of spare parts. It will be logistically unsupportable by 1993. Furthermore, the system does not produce a digitized radar output compatible with newer FAA search radars (e.g., ARSR-4, ASR-9). This will become a major factor with respect to future interoperability with the "end-state NAS" Area Control Facility (ACF) concept. The Air Force plans to replace the system with a compatible digital radar. The GPN-12 at MCAS Point Mugu will be replaced by an ASR-8 in FY 1990.

The most common military primary surveillance radar system is the ASR-8. Utilized throughout the NAS by the FAA, the ASR-8 is a solid-state radar with dual-channel architecture. Redundancy of the components has been further expanded to include a dual-drive pedestal and solid-state modular klystron transmitter, which makes the ASR-8 more reliable and maintainable than the ASR-7. The peak power output of the klystron increases aircraft detection at long ranges. In addition, the ASR-8 includes a dual-beam, tower-mounted antenna that rejects surface clutter targets. A range/azimuth gate generator provides programmable range/azimuth windows for clutter rejection and improved target enhancement. Weather detection capability is improved over that of the ASR-7; however, the system lacks a separate weather receiver capable of supplying weather data independent of search radar information. Since the receiver-transmitter is necessarily peaked for air surveillance, it sacrifices weather detection capability. The ASR-8, like the ASR-7, does not provide radar or weather data in a NAS-compatible digital format. The majority of the ASR-8 radars were procured under an FAA contract for civil and military applications. ASR-8s are in use at the Army Radar Approach Controls (ARACs) at Fort Hood, Texas, and Fort Sill, Oklahoma. The same system, designated the AN/GPN-27, operates at 33 Navy and Marine Corps ATC facilities in the NAS.

The Air Force AN/GPN-20 is a lower-powered version of the FAA ASR-8 equipped with a magnitron radar transmitter and frequency stabilization to reduce drift. The GPN-20 is compatible with the military standard ATC Beacon Interrogator, the TPX-42A. Programmed for service through the 1990s, the system is used at 28 Air Force facilities in the NAS and at the Fort Campbell ARAC in Kentucky. The GPN-20s located at major approach control/range control installations will probably be replaced by the ASR-10 radar system presently under development for the FAA.

2.1.1.1.2 Secondary Radar Systems

Military surveillance (primary) radar is normally augmented by the addition of a ATC radar beacon system (ATCRBS), a secondary radar which interrogates and receives coded responses from aircraft transponder equipment. The DoD standard ATCRBS is the TPX-42A(V). The TPX-42A(V) utilizes dual interrogators and 12 to 22 inch indicators. In its hardwired configuration, this non-programmable, numeric beacon decoder system provides the capability to maintain real-time primary radar video in registration with synthetic position symbology, numeric identity (aircraft discrete beacon code), and altitude data. The TPX-42A in its simplest form is used in less than a dozen Air Force installations in the NAS.

Most military surveillance facilities have enhanced beacon systems that permit interface with the present NAS. The Fort Campbell ARAC, over 50 Air Force installations, and 20 Navy and Marine Corps shore facilities use TPX-42 systems that have been modified by the addition of a Programmable Indicator Data Processor (PIDP). The modifications involved replacing the existing hard-wired indicator data processor with a general purpose programmable computer that permits computer tracking of secondary radar returns, computation of ground speed, and generation of alphanumeric target data blocks The modified system, the TPX-42(V)10, provides the capability for intra-facility semi-automatic hand-offs. In addition, some locations have established an inter-facility semi-automatic hand-off capability through data link communication with the serving FAA Air Route Traffic Control Center (ARTCC). The system includes false target discrimination and Minimum Safe Altitude Warning (MSAW) features. DoD plans to further modify the beacon system to increase its processor speed and memory capacity in order to incorporate conflict alert functions and to meet future ATC requirements.

2.1.1.1.3 Automatic Radar Tracking Systems

The Fort Hood and Fort Sill ARACs and the FAA Radar Approach Control (RAPCON) at Edwards Air Force Base (AFB), California, use the Automated Radar Terminal System (ARTS) II. The ARTS-II is a radar data automatic digital processing and presentation system that is integrated with the primary and secondary (ATCRBS) terminal radar systems. The system produces computer-generated alphanumeric target information as overlays on surveillance radar Plan Position Indicator (PPI) displays from data reported by transponder-equipped aircraft. The ARTS-II presents real-time video signals (decoded video) representing aircraft identification, altitude, ground speed, and flight plan information. It provides data link connectivity to the serving FAA Air Route Traffic Control Center (ARTCC) and the capability for semi-automatic inter-facility hand-offs.

The unique surveillance systems located at Fort Rucker in Alabama, Nellis AFB in Nevada, and the Navy's Fleet Area Control and Surveillance Facilities (FACSFAC) warrant recognition as leading examples of evolving military radar applications.

The Cairns ARAC at Fort Rucker employs an ASR-5 surveillance radar augmented by an ATC Beacon Interrogator-5 (ATCBI-5) and the ARTS IIIA radar/beacon tracking level automation system. The ARAC controls a wide range of civil and military flight operations through a mosaic network of radars encompassing the

Army Aviation Center area of operations. The first military ASR-9 radar is scheduled for installation at Cairns. The ASR-9 is a solid-state surveillance radar with a separate weather channel capable of presenting weather and target information simultaneously. With the exception of the weather receiver, the antenna, and some monitoring/control sub-systems, the ASR-9 is a dual channel, totally redundant system. Improved radar data processing and moving target detection functions significantly reduce the effects of angle clutter, weather, and ground vehicular traffic. The digital output of the ASR-9's Surveillance and Communication Interface Processor (SCIP) is compatible with and interfaces with PPI displays, ARTS-III, ARTS-II, TPX-42, and BRITE. The SCIP also provides the interface between the surveillance site and the ARTS. When the ASR-9 is installed in FY 1990, Cairns will be the first Army system that is fully compatible with "end-state" NAS requirements.

The Nellis AFB air traffic control facility utilizes two prototype ASR-9 radars (GPN-25s) and several FAA en route radars, processed and integrated by the En route Automated Radar Tracking System (EARTS), for terminal and en route air traffic control and for range control of the Tactical Fighter Weapons Range complex. The EARTS is an en route center radar-processing system capable of processing radar data from 15 sensors in a mosaic display and providing conflict alert, Mode C intruder warning, and minimum safe altitude warning capabilities. The EARTS can also present a single radar sensor display for terminal approach control services. The Nellis AFB enhanced EARTS, further augmented with ARTS III integration, operates as a NAS facility. EARTS is also used to link the Alaskan (Air Force) FPS-117 long-range radars to the FAA ARTCC in Anchorage, Alaska.

Using a similar multi-sensor architecture, four Navy coastal FACSFACs use the FACSFAC Air Control Tracking System (FACTS) to monitor and control air operations in offshore warning areas using information from a mosaic of FAA and Air Force long-range radars as well as data from the Navy's Tactical Data System. FACTS, designated the FYK-17(V), can accept input from other sensors, such as the FAA Discrete Address Beacon System (DABS), and interfaces with the National Data Interface Network (NADIN) and the Electronic Tabular Display System (ETABS) under development by the FAA. The FACTS-3200, an advanced 32 bit digital processor, is being added to the system to further enhance capabilities. FACTS is also employed for military range control operations at Naval Air Station Fallon, Nevada, and Hill AFB, Utah, and will be installed at the new FACSFACs planned for Naval Air Stations Roosevelt Roads in Puerto Rico, Pensacola in Florida, and Whidbey Island in Washington.

In addition, several mobile and tactical radars, such as the Navy's FPN-36 and CPN-4A radars are being used at low-traffic density military airfields as fixed-base ATC systems. These older ASR/PAR units will be retired from service use when either the facilities are closed or ASR-8 systems are made available. The FPN-36 is a Navy air-transportable, all weather, surveillance and precision approach radar set designed for use at forward airstrips and heliports. The system consists of one radar and two control-indicator groups, that contain indicators, power supplies, and controls for remote operation. The CPN-4A is a self-contained, mobile radar incorporating an S-band ASR set with a range of 30 NM, and an X-band Precision Approach Radar (PAR). It also contains Moving Target Indicator (MTI) equipment for both radars, communications radios, environmental sub-systems, and supporting equipment for remote operation. The FPN-36 is in service at MCAS Quantico, Virginia, and at the

Naval facility on San Nicolas Island, California. The CPN-4A is used at Naval Air Stations Imperial Beach, California, and South Weymouth, Massachusetts.

The Army uses the surveillance capabilities of the tactical FPN-40/TSQ-84 radar set to provide radar coverage for 11 Army Air Fields (AAF) throughout the NAS. The Air National Guard operates an MPN-14 mobile radar as a fixed Approach Control at Martinsburg, West Virginia. The capabilities of these last two systems will be discussed in the following sections.

2.1.1.2 Terminal Control and Landing Systems

This section describes fixed facilities that provide terminal control and landing functions. Military Air Traffic Control Towers (ATCT) and associated equipment are discussed in the beginning of this section, after which precision landing systems are examined.

2.1.1.2.1 Control Towers

Military ATCTs control or provide services to aircraft operating in the terminal area under Visual Flight Rules (VFR) by means of radio communications, visual signals, and other devices. Tower controllers issue takeoff, landing, and surface movement clearances to all aircraft operating at controlled airports under VFR and Instrument Flight Rules (IFR). Some control towers also incorporate surveillance radar capabilities.

The age and equipment status of control towers at military airfields in the NAS varies considerably. Standards for tower cab size, configuration, and equipment are established by each military service independently. All services are modernizing or replacing older ATCTs to correct facility problems related to tower location, height, and size, and to reduce other limitations attributable to aging environmental and communications equipment and facility safety sub-systems. Within the NAS, Air Force and Army plans entail combining tower and Ground Controlled Approach (GCA)/RAPCON facilities into new single or collocated buildings, where practicable and economically justifiable.

Much of the individual service planning for upgraded tower facilities is directed toward improving communications capabilities and serviceability. Tower communications capabilities are covered in Section 2.1.1.4.1. Air Force ATCT modernization includes the installation of the Standard Communications Control System (SCCS), a communications upgrade program. The SCCS plan calls for the installation of FAA-designed wrap-around consoles in all towers scheduled for the SCCS installation. The new consoles offer greatly improved floor space utilization, two-place local and ground controller positions, and four channels at the flight data position. Similar programs are underway to enhance key Army, Navy and Marine Corps towers.

Most DoD towers are equipped with Bright Radar Indicator Tower Equipment (BRITE II). BRITE II provides an ASR raw data display of all aircraft. The display provides the tower controller with a complete picture of aircraft operating in the surrounding area and enables him to provide appropriate separation between incoming aircraft.

Service plans call for upgrading the BRITE II system to a digitized format. The Air Force and the Army are obtaining Digital BRITE (DBRITE) systems under a joint procurement program with the FAA. In addition to providing the

altitude readout and aircraft call sign information of the BRITE II, the newer system enables the tower controller to perform semi-automated hand-offs to associated RAPCON and ARTCC facilities with similar capabilities. The DBRITE is scheduled to be installed at 107 Air Force and 36 Army towers.

Similar in capability to DBRITE, the UYX-1(V) Data Processing Set, commonly known as BRANDS, is a real-time alphanumeric generation and digital scan conversion kit that will be used in conjunction with other ATC equipment at Naval and Marine Corps Air Station control towers. BRANDS is a modular system composed of signal and control data processors and two video indicators. The system can also be used as an en route navigational and instrument approach aid. BRANDS is replacing the FAA analog BRITE equipment currently being used in most Department of the Navy ATCTs.

2.1.1.2.2 Precision Landing Systems

Precision landing capabilities at military installations are generally provided by PAR systems, instrument landing systems, or a combination of both. The systems are considered "precision" because they provide azimuth (course line), elevation, and distance information to pilots. A PAR system relies on a controller to interpret the radar presentation and issue guidance information for pilot execution. The instrument landing system provides electronic guidance signals to an aircraft receiver which are then converted to cockpit instrument displays that interpreted by the pilot to fly the aircraft to the runway.

2.1.1.2.2.1 Precision Approach Radar

A variety of military PAR systems are used at fixed sites throughout the NAS. Although each military service uses unique equipment, the Army FPN-61, Air Force FPN-62, and Navy FPN-63 are all essentially the same type of fixed base precision radars. All of the systems provide the final controller with aircraft azimuth, distance, and elevation information needed to guide the aircraft to the runway. These radars are non-computerized, manual systems that require controller interaction. The Army's FPN-61 is used at Ft. Campbell AAF, Kentucky. The FPN-62(V) system serves 45 Air Force airfields worldwide, 35 of which are in the NAS. The FPN-63 provides PAR capability to 37 of the Navy and Marine Corps Air Stations in the NAS.

The FPN-40/TSQ-84 is the Army's principal all-weather ASR and PAR system at airfields/heliports in CONUS and Europe. It serves as a fixed GCA in all but two of the Army Airfields in the NAS. The FPN-40's X-band GCA radar yields height, precision approach control, and airport surface movement detection capabilities. It provides non-simultaneous azimuth, elevation, and range information for aircraft up to 10 miles from touchdown.

The GPN-22 (Hi-PAR) is a solid-state, phased-array, high-performance, precision approach radar used by the Air Force. It can simultaneously track and control six aircraft to 15 NM range. Radar operational capability far exceeds the present FPN-62 in terms of weather penetration and volume coverage. The GPN-22/22A is used at 30 Air Force facilities worldwide, predominantly at overseas locations. Eight units are employed at airfields in the NAS.

In general, replacement systems for the PAR are not planned, due to the selection of the Microwave Landing System (MLS) as the future precision landing

system for DoD fixed-base installations. However, the PAR function will be required during the transition to MLS equipment.

The Automatic Carrier Landing System (ACLS) is a precision guidance and control system used on aircraft carriers and select air stations to provide instrument capability for carrier based aircraft. The ACLS uses the SPN-42A, a pencil-beam, precision approach radar, to obtain precise tracking information on approaching aircraft. ACLS computers integrate the radar tracking data with pre-programmed aircraft performance data to generate precise guidance information and flight control commands for the aircraft. These commands are transmitted to the aircraft via a UHF data link. The ACLS is capable of operating in three modes: Mode I - completely automatic operation (including aircraft autopilot) to aircraft touchdown; Mode II - guidance and control information transmitted to the aircraft and displayed on cockpit flight controls for a manual approach and landing; and Mode III - guidance and control information used by a controller for voice commands to the pilot. The ACLS is used at Naval Air Stations Cecil Field, Lemoor, and Miramar in California, Oceana in Virginia, and Whidbey Island in Washington.

2.1.1.2.2.2 Instrument Landing Systems

Instrument Landing Systems (ILS) are solid-state, all-weather guidance systems that provide highly reliable localizer, glideslope, and marker beacon facilities for aircraft engaged in airfield approach and landing operations. The GRN-27 fulfills this capacity at 44 Air Force bases in the NAS. The TRN-28 is a Ka-band instrument landing system that is used as a fixed-base system at most Department of the Navy airfields. The Army uses four different ILS systems, including the FAA Mark I, at five airfields in the NAS. As previously mentioned, future military requirements for precision landing systems will be met by the MLS.

The Air Force GRN-29 is a modified version of a presently used FAA solid-state ILS system. The GRN-29 has a positive interlock feature that can be used with other GRN-29s at locations requiring a multiple system capability. This ILS has been identified to meet critical mission requirements for precision guidance systems that cannot await the production and deployment of the MLS. The 91 GRN-29s located at air bases in the NAS are logistically compatible with other systems presently in use.

The MLS is a digital, all-weather precision approach and landing guidance system that uses solid-state and micro-processor technologies to provide greater reliability and flexibility and easier maintainability than most ILS systems. It provides aircraft with multiple approach paths and pilot-selected azimuth and glide path angles. Aircraft avionics derive angular information by measuring the time difference between successive passes of fan-shaped azimuth and elevation beams projected in front of and to the sides of the runway by an MLS transmitter. Precision Distance Measuring Equipment (DME/P) transmitting in the L-band provides range information. The MLS can be located in difficult terrain locations. The MLS also provides 200 channels, continuous angle and range indication, improved signal quality, reduced sensitivity to siting environments, and wider guidance coverage sectors.

2.1.1.3 Position/Navigation Systems

2.1.1.3.1 Global Positioning System

The Global Positioning System (GPS) is a space-based radio positioning and navigation system that will provide position, velocity, and system time to suitably equipped ground and airborne users. Twenty-one NAVSTAR satellites and three on-orbit "spares" will make up the space segment of the system. The satellites broadcast messages at L-band frequencies that allow the user to determine position, velocity, and time. GPS receivers will be installed on aircraft, ships, and land vehicles, or carried in man packs. The DoD intends to use the GPS in the NAS, along with integrated aircraft Inertial Navigation Systems (INS) as the primary navigation system in all phases of flight down to non-precision approach. For civil aviation, the FAA has stated that GPS could be used initially as a supplemental means of navigation. They are now evaluating its use as a sole means of navigation. GPS satellites are being built and launched, with the full constellation expected to be deployed in orbit by 1993. The primary (military) user equipment is in production. Many companies, both national and international, are building civil receiver equipment.

2.1.1.3.2 VHF Omni-directional Range (VOR)

A VOR is a navigational aid (NAVAID) that transmits relative bearing and track guidance information to aircraft, along with a coded identification tone and/or voice identification to inform the pilot of the station selected. VOR is the ICAO standard short-range NAVAID and the primary NAS system for the en route structure and for transitioning from the en route to the terminal structure. It is also used as a non-precision approach and landing aid. Military VORs vary from the Air Force's short-range (50 watt) FRN-31 to the longer-range (200 watt) FRN-37 and FRN-38, as well as the Army's FRN-41(V). The FRN-44, which is replacing previous model Air Force VORs, is a solid-state NAVAID designed for automatic, remote operation. The FRN-36 is common to Department of Navy airfields. Like the FRN-44, the FRN-36 is designed for automatic, unattended operation, directed and monitored by a remote control monitor located in an air traffic control facility. In summary, 31 Air Force, 23 Army, and 8 Navy independent VORs will be in operation throughout the 1990s, until GPS is operational and all aircraft are GPS-equipped.

2.1.1.3.3 Tactical Air Navigation (TACAN)

The TACAN is a UHF fixed-base radionavigation beacon which provides relative bearing and distance information to aircraft. TACAN, the primary tactical air navigation system for the military, provides line-of-sight, directional coverage in excess of 200 NM. The Army maintains the GRN-20 and GRN-21 TACAN systems. The URN-25 is the primary navigational aid used by the Navy and Marine Corps to support both en route and terminal navigation requirements. The station is designed for unattended, automatic operation with remote control monitoring. The Air Force maintains approximately 120 TACANs worldwide, the majority of which consist of GRN-19 and -20 series systems that are employed as terminal NAVAIDs. Both systems are marginally reliable and logistically unsupportable. Although replacement FRN-45 TACANs have been procured, system component failures have placed the conversion program on indefinite hold, with less than a dozen FPN-45 systems operational. With the exception of a few Navy installations, DoD land-based TACANs will be phased out in favor of the GPS by

1998. However, the phase out date is contingent upon the acceptability of GPS (or GPS integrated systems) as the sole navigation system for military use in controlled airspace.

2.1.1.3.4 VHF Omni-Range and Tactical Air Navigation (VORTAC)

Military VOR and TACAN systems are frequently collocated to form VORTAC facilities, particularly where the facility is part of the national en route system. The Air Force operates 18 VORTACs which normally consist of a FRN-37/38 and a GRN-20. In addition, the FRN-43 system incorporates both VOR and TACAN, coaxially located and operating simultaneously. Used in the VORTAC configuration, the station radiates both VOR and TACAN signals as discrete navigation aids along with coded station identification. The Air Force VORTAC Modification Program will replace all tube-type VOR and TACAN equipment with the FRN-43 VORTACs, FRN-44 VORs or FRN-45 TACANs. Collocation options, using the FRN-43, are being reviewed. However, the component failures plaguing the FRN-45 are common to the FRN-43, which has delayed the VORTAC part of the modernization effort.

2.1.1.3.5 Non-directional Beacon (NDB)

The NDB is an omni-directional LF radio beacon commonly used as a boundary marker for an ILS or as a homing beacon by aircraft. The transmitter is automatically keyed for station identification. The system is normally installed at an unattended remote site, but may be remotely controlled for aircraft communications. The two systems in common DoD use are the URN-5 and the NAUTEL NDB.

2.1.1.3.6 Long Range Navigation (LORAN)

The LORAN is a pulsed, hyperbolic system that determines receiver position by measuring the difference in the time of arrival of RF pulses radiated by a chain of synchronized transmitters that are hundreds of miles apart. Designed originally as a military over-water navigation system, the current LORAN-C network provides coverage of the coastal U.S., the Aleutians, the Bering Sea, the Far East, Northern Europe, and the Mediterranean Sea. The U.S. Coast Guard's national network also covers approximately two-thirds of the conterminous 48 states. The recent surge of civil aviation users led to the development of Coast Guard/FAA plans to complete national overland coverage. The FAA will fully implement LORAN-C in the NAS by completing the mid-continental system and by approving non-precision approaches at all airports that have adequate coverage. DOD will phase-out its use of the LORAN-C by the end of 1994 and transfer overseas facilities to the respective host nations.

2.1.1.3.7 OMEGA

The Omega system is an oceanic radionavigation system that was developed by the Navy with assistance from the Coast Guard and several partner nations. It uses a continuous wave comparison of signal transmission from pairs of stations that transmit time-shared Very Low Frequency (VLF) signals on four frequencies, plus a station unique frequency. Although its accuracy is limited to 2-4 nautical miles, Omega provides a worldwide, all-weather radionavigation capability to air and surface users. A number of air carriers and general aviation aircraft operators have received FAA approval to use Omega as an update for their self-contained systems or as a sole means of navigation on oceanic

routes. The use of Omega by military aircraft will be phased out by the end of 1994, in favor of GPS.

2.1.1.4 Communications Systems and Other ATC Support Equipment

Communications is the critical NAS component in the control of air traffic. Communications functions in the NAS are accomplished by air-ground exchanges between control facilities and aircraft, and by inter-facility and intra-facility communications. Air-ground communications allow the pilot to obtain and change flight clearances; to report flight progress and weather observations; to request position information in the event of emergency; and to obtain weather, airspace, and traffic advisory information and instructions from ATC specialists. These exchanges are normally accomplished via voice communications on Very High Frequency (VHF) and Ultra High Frequency (UHF) radios. The information exchanged within and between ATC ground facilities includes flight plans, radar data, aircraft positions, traffic control coordination messages, clearances, weather products, navigation aid status, and equipment status for maintenance purposes. These exchanges make use of both voice and digital data link and may use landline, microwave, or radio.

The communications equipment addressed in this assessment include the UHF/VHF radios, communications consoles, switching systems, and emergency and intra-facility communications sub-systems common to most military ATC facilities. Lessor components, such as loudspeakers, controls and control monitors, headset-microphones, light guns, foot switches, and power supplies, are important to system performance but are outside the scope of this report.

2.1.1.4.1 Control Tower Communications

Fixed control tower communications radios are more standardized than is suggested by the dichotomy of structures and tower cab configurations found in military service. VHF components such as the GRT-21 single-channel transmitter and the GRR-23 receiver combine with the GRC-211 multi-channel transceiver to create a modern, reliable, solid-state system capable of 25 KHz channel spacing. UHF components include the GRT-22 transmitter, the GRR-24 receiver, and the GRC-171 or GRC-215 multichannel transceiver. The twenty-series VHF/UHF radios are used by most Army, Navy, and Air Force tower and radar facilities in the NAS. However, standardization of the VHF/UHF radios did not correct the communications limitations that result from the use of dissimilar supporting systems, including communications control and switching systems, FM radios, antennas, remote cables and landline systems, and other peripheral devices.

Tower communications consoles are being upgraded by each service, independently. The modernization effort varies considerably in relation to the types of equipment being replaced, the scope of the modernization program, and the degree of completion.

The Air Force replaced obsolete console equipment with the GSA-135 tower console in most control towers. The GSA-135 is also used in Army ATCTs. The console has provisions for meteorological indicators, crash alarm systems, runway lighting panels, and telephone key components. Four-channel key equipment controls up to 16 UHF and VHF radio channels at ATC positions. Four channels are also available for flight data. The Air Force SCCS plan, a communications upgrade program, includes the installation of FAA-designed wrap-around consoles in select ATCTs scheduled for SCCS modification. The Army is also

retrofitting ATCTs with the FAA consoles at several key airfields with high traffic density. The Navy and Marine Corps standard tower console is produced by the Naval Electronics Systems Center in Charleston, South Carolina.

The GSA-135, FAA wrap-around, and other types of consoles in or slated for military ATCTs will satisfy near-term requirements into the 1990s. However, most military service ATC planners recognize that future increases in ATCT productivity and efficiency will be gained from improved console configuration and communications automation, similar to that found in the emerging FAA family of sector/tower suites.

The automation of ATC systems that is occurring as part of the FAA's NAS Plan programs will rely increasingly upon improved data communications, particularly flight data entry and printout systems. The Flight Data Input/Output (FDIO) system now installed at FAA ARTCCs provides the air traffic data link between all ATC facilities within the NAS. Through the use of FDIO, flight plan information is entered and removed from the system. This information is automatically transferred between compatibly-equipped facilities and converted into the flight progress strips used to control air traffic and to process flight information. The focal points for this information are in FAA ARTCCs where the central host computers are located. The FDIO is installed at approximately 20 high-density military ATC tower/radar facilities. It interfaces with the Flight Data Entry and Printout (FDEP) system that is still in use at most military and civil ATC terminals. Like the FDIO, FDEP is used to enter and transfer flight progress information. FDEP promotes intra-facility transfer of aircraft control and serves as the current data interface between the FAA ARTCCs and most military terminal ATC facilities. However, the FDEP is becoming increasingly unreliable and expensive to maintain, and will be replaced by the FDIO at the approximately 90 remaining FDEP-equipped military installations as part of an outyear FAA procurement. As an interim measure, DoD has installed the Flight Data System (FDS) at facilities planned to receive FDIO. FDS is a microcomputer-based FDEP emulation system that uses FAA software compatible with FDIO.

2.1.1.4.2 Radar Facility Communications

In general, military radar facilities employ or share the twenty-series family of VHF/UHF radios described above. Beyond this common equipment, military radar facility communications sub-systems (e.g., intercom, telephone, landlines, antennas, etc.) are diverse in terms of the types used and their capabilities. The types of communications control systems in use vary among the services and among the facilities within the same service. All systems provide the same essential function: to mount and house the radio controls, components, key systems, displays and ancillary control equipment needed by the ATC controller. Due to the variation in components and the similarity in purpose, only key communications systems are addressed. Communications switching systems are discussed in Section 2.1.1.4.3.

Thirty-seven Navy and Marine Corps fixed ATCT/radar facilities are being upgraded with the installation of the FSC-104(V), an independent emergency communications system (ECS) that is capable of transmitting and receiving nine separate VHF and UHF AM ground-to-air channels and one VHF FM crash net radiophone channel. The FSC-104 combines the hot-standby communications system and the ECS into a single system. System configuration provides control, monitoring, and switching of the radiophone channels at the operator positions in the control tower and the radar facility. A fully automatic quality monitoring

system ensures the quality of the communications and the reliability of the system by providing audible and visual alarms of system discrepancies to operator positions along with a hard copy printout for maintenance personnel. The FSC-104(V) is currently operational at MCAS Beaufort, South Carolina.

2.1.1.4.3 Communications Switching and Control Equipment

The OJ-314/OA-7621 communications switching and control system is common to many military tower and radar facilities. It was originally designed for the Navy to be a modular system that integrates radio, intercom, and telephone (OA-7621) sub-systems. The system can provide both small (3 position, 15 channels) and large station configurations (60 positions, 75 channels) with console amplifiers; dial modules; radiophone, interphone, and landline select modules; and foot switches and headsets. The system is used extensively by the Navy and the Air Force.

In addition to the OJ-314/OA-7621, the Air Force employs a 4-channel communications switching and control system in ATCTs. The system is modular, solid-state, and adaptable to the wide variety of control positions and radio configurations currently in service. A third system, the GSC-37, is also used in some fixed RAPCONs. The GSC-37 is a smaller version of the OJ-314 augmented with request-and-acknowledgement and conference patch features. Under the SCCS program, older systems have been replaced with the OJ-314 at over 100 Air Force ATCTs and 27 fixed radar facilities.

The Army utilizes the FSC-92 ATC communications switching system, a micro-processor controlled system that includes tower consoles for local control, ground control, flight data and equipment/crash alarm; radar control and radar flight data consoles for GCA; and flight operations consoles. The system provides the interface devices necessary to interoperate with existing VHF/UHF radios, commercial and service telephone systems and inter-/intra-facility communications through government channels. The system is operational at 28 Army installations and will replace obsolete equipment at four more facilities in the NAS by 1990. A scaled-down version of the FSC-92, called the LATCOM (Low Activity Tower Console), is replacing communications switching systems at 37 low-to-moderate air traffic density locations in the NAS. LATCOM is a modular system of three electronic assemblies dedicated to local/ground control, flight data, and flight advisory functions. The system provides all of the communications, electronics, and meteorological equipment needed to operate an ATCT.

A mix of systems are used at Department of Navy facilities. The OJ-314 is used at 19 Navy and Marine Corps air stations in the NAS. Fourteen facilities rely on the FSA-58 communications central control, a modular switching system that links from five to 20 hardwired, "patch chord"-configured positions. Eleven other installations have the FSA-52 communications control system. Functionally equivalent to the OJ-314, this older system links radio, telephone (OA-7621), intercom, and landline sub-systems for from 16 to 23 installed ATC positions. Up to 60 radio channels are accessible. The Navy plans to replace the FSA-52 with the new Integrated Voice Communications Switching System (IVCSS). The IVCSS will provide ATC controllers with ground-to-aircraft and inter-/intrafacility communications capability. Controllers will have access to and control of available communications circuits on a programmable basis. The IVCSS is modular and employs distributed, micro-processor controlled switching to allow for a high degree of flexibility in configuring each console

(or operator position) to satisfy unique requirements. Ultimately, this system will also replace the OJ-314.

2.1.1.4.4 Other Support Equipment

Other systems important to the conduct of military ATC functions include secure, anti-jam communications systems and automated weather systems capable of direct input to ATC.

The DoD-wide wartime requirement for secure, anti-jam voice communications has placed additional requirements on select fixed ATC facilities. Some GRC-171 UHF transceivers are being modified as part of the HAVE QUICK program, and will provide a limited frequency-hopping system to counter the UHF jamming threat. HAVE QUICK and other anti-jam, secure communications programs primarily apply to tactical ATC systems and will be discussed in related sections of this report, beginning with Section 2.1.2.4.

Weather information is often critical to the safe and efficient control of air traffic. Most ATC facilities rely upon weather station personnel and telewriter/telephone transmission to receive meteorological observation information. The display of information on existing weather conditions is limited to wind, pressure altitude, temperature, and runway visual range readouts from airfield sensors. To correct for the lack of accurate, real-time weather information, automated systems are being developed by military and joint agency programs. Two programs, the Next Generation Weather Radar (NEXRAD) and the Air Force Automatic Weather Distribution System (AWDS), could significantly improve the quality and availability of weather information at ATC facilities.

The NEXRAD program consists of defining, developing, procuring, and installing a new S-band Doppler weather radar for en route applications. This program will establish a national aviation weather radar network of over 130 radar units linked to interactive principle user display units that provide observers with accurate aviation weather products (e.g., precipitation reflectivity, wind velocity, turbulence indicators, etc.). The system combines high-signal accuracy with advanced processing techniques to perform comprehensive storm surveillance and severe weather prediction. The program is jointly-funded by the Department of Commerce, DoD, and FAA. Key DoD installations are scheduled to receive NEXRAD principle display units. Some installations will host radar sites. The initial operational test and evaluation of the NEXRAD system at Norman, Oklahoma, will be completed in August 1989.

The Air Force AWDS program will automate many airfield weather station functions and provide the information to computer displays in ATC facilities and flight operations areas. The system will also store and process Notice To Airmen (NOTAM) information for flight planning and ATC actions. AWDS will be linked to national weather and NOTAM networks to capture regional and national information. Army and Air Force facilities will receive AWDS systems. The Navy is procuring a similar capability called the Navy Environmental Distribution System for Navy and Marine Corps installations.

2.1.1.5 Airspace Management Systems

Airspace management systems are included in this report since they too must interface with existing NAS control systems. Airspace management efforts are normally directed towards military Special Use Airspace (SUA), airspace set

aside for aerial activities that must be contained and segregated due to their nature, or from which non-participating aircraft must be separated to ensure aviation safety. Special use airspace includes prohibited areas, restricted areas, warning areas, military operations areas, controlled firing areas, and alert areas. Air traffic in and out of SUA and airspace utilization are important factors in the smooth flow of air traffic in the NAS. The FAA and DoD recognize the importance of this segment of ATC, a segment largely ignored until the national demand for air traffic services and expeditious routing threatened the use and existence of military SUA. While all delegated airspace has a scheduling military office, only a few systems possess automated management functions, such as schedule deconfliction. The following airspace management systems are area-specific programs dedicated to the effective use of delegated airspace and routes.

2.1.1.5.1 R-2508 Automated Scheduling System

The R-2508 Automated Scheduling System (RASS) is a real-time decision support system designed specifically for resource management (i.e., people, hardware, airspace, communications frequencies, etc.) of the R-2508 (Edwards-China Lake) Range Complex. It consists of a network of mini processors dispersed and configured to meet the needs of the agencies controlling and using the complex. The system provides: flight mission profile building; operations research forecasting and requirements analysis; flight schedule request entry; airspace and air traffic control conflict analysis and resolution; schedule dissemination; real-time mission monitoring and control (including schedule adjustments, completions, and cancellations); and airspace utilization reporting and analysis. Expansion capabilities include autodin message preparation, Defense Data Network interface, and interface with other similar FAA/DoD air traffic control and airspace management systems.

2.1.1.5.2 Military Airspace Scheduling Management System

The Military Airspace Scheduling Management System (MASMS) is a centralized, semi-automated management system operated by the Air Force Strategic Air Command (SAC) to schedule and deconflict the use of SUA and Airspace for Special Use (e.g., military training routes, aerial refueling tracks) dedicated to the military. The system incorporates all training routes and SUA associated with SAC's Strategic Training Range Complex (STRC), as well as collocated routes and airspace dedicated to other military agencies.

2.1.1.5.3 Fleet Area Control Scheduling System

The Fleet Area Control Scheduling System (FACSCHED) is the computer-based airspace scheduling and tracking system used by Navy FACSFACs. Schedulers use microcomputers to record and enter user reservations for FACSFAC-controlled SUA into FACSCHED. The system produces comprehensive schedules, ATC data strips, and utilization data and analyses. FACSCHED is a local system that aids in the management of the SUA delegated to a single FACSFAC installation.

2.1.1.5.4 Military Airspace Management System

The Military Airspace Management System (MAMS) is a planned, automated, national DoD system designed to control the use of military SUA and airspace for special use. The system will consist of a distributed, wide-area, computer network that allocates airspace, optimizes the shared use of airspace among

military users by interfacing airspace requirements, deconflicts airspace and military training routes, and documents airspace scheduling and utilization. The MAMS will centrally integrate the separate SUA schedules from the national network into a time-phased composite, report the composite SUA schedule to FAA flow control, and provide real-time data to military management activities. The system is in the design phase.

2.1.1.5.5 National Airspace Management Facility

The National Airspace Management Facility (NAMFAC) is a planned system, like the MAMS. From a centralized system collocated with the FAA Central Flow Control Facility of the Air Traffic Control System Command Center, NAMFAC will receive SUA advanced schedule data from military sources and forward the data to individual ARTCCs and Flight Service Stations. The NAMFAC will also provide real-time update to SUA schedules and summary analyses of airspace utilization.

2.1.2 Tactical Systems

Tactical air traffic control and landing systems (ATCALS) are used by all military services to control aircraft at overseas locations as well as within the NAS. In most cases, their use in the NAS is limited to military field training exercises or for the temporary replacement of fixed equipment, and is initiated only after extensive coordination with adjacent military and FAA fixed ATC facilities. The organization of the following sections on tactical ATCALS is similar to the format followed for the preceding fixed base sections. The systems described are the most common tactical systems in the DoD inventory.

2.1.2.1 Surveillance Systems

Mobile radar systems vary considerably in type and age, from 1950s vintage radar moveable only by road or C-5 transport, to compact, modern, tactical systems capable of rapid deployment. Most mobile radar systems possess both surveillance and precision approach capabilities and, thus, are discussed in the next section. Where separately identifiable, PAR component systems are described in Section 2.1.2.2.2.1.

2.1.2.1.1 Mobile Primary Radar Systems

The FPN-40/TSQ-84 described earlier is a lightweight, transportable ASR/PAR system. It is the Army's principal all-weather radar in CONUS and Europe. The FPN-40 has a surveillance range of 25 NM for small aircraft and 40 NM for large aircraft and a height-finding capability of between 500 and 50,000 feet within 30 NM of the radar site. Produced in the late 1950s, the system has been modified extensively to integrate modular, solid-state components, increased power and performance characteristics, and the TPX-41 Identification Friend-or-Foe (IFF) set. The combined FPN-40 and TPX-41 unit is designated the TSQ-84.

Air Force mobile surveillance systems include long-range (TPS-70, TPS-43E, and AWACS) and short-range (MPN-14, TPN-19, and TPN-24) radars. Both the TPS-43E and TPS-70 are S-band radars with a 240 NM coverage range that are dedicated to the tactical air defense mission. The TPS-43E is a light-weight, air-transportable, radar set with an expanded shelter. It is being modified to replace the current radar antenna with an ultra-low sidelobe, waveguide array

antenna which improves its anti-jamming and anti-detection capabilities. The radar was designed for remote operation under extreme environmental conditions. Although currently used for air defense, the TPS-43E can function as an autonomous ATC radar when linked to an operations center, or as an integral part of an airspace management system. Like the TPS-43E, the TPS-70 radar provides high-performance, 3-dimensional surveillance coverage in a tactical environment. The solid-state radar employs a planar array antenna, random and automatic frequency agility, and automated digital output. It can be operated remotely or as part of a self-contained C^3 center.

The Airborne Warning and Control System (AWACS), another air defensive system, is a mobile, high-capacity radar station and command and control center built into a Boeing 707 airframe designated the E-3A. Radar, identification, data processing, display, and communication functions are integrated and include an IFF capability with an interrogation function. The radar can look down, detect, and track targets within approximately 250 NM of the aircraft. It can also perform ATC or provide information for ground ATC facilities, both of which occur frequently during large military training exercises employing AWACS-controlled aircraft. External communications are accomplished using HF, VHF, and UHF radios as well as the Joint Tactical Information Distribution System.

The MPN-14 is a self-contained mobile GCA radar that consists of a search radar with a 60 NM range, a precision radar, and the radio equipment for ground-air communications. The MPN-14 includes the radar indicators and associated equipment necessary to provide limited RAPCON control capability. The radar is the mainstay of the Air Force tactical ATC system. However, the 26 MPN-14 mobile RAPCONs are characterized by late 1950s technology and are logistically unsupportable. The current MPN-14 "K" modification program is an interim measure designed to extend the utility of the system until a new mobile RAPCON system can be fielded. Even after modification, the MPN-14K system will still lack the auto-tracking, operating positions, and survivability features needed to function in a wartime environment.

The TPN-19 landing control central is an Air Force solid-state, modular, tactically-mobile GCA and RAPCON facility. The GCA configuration consists of the TPN-24 ASR, the TPN-25 PAR, and an operations center. The TPN-24 is a solid-state, dual-channel, dual-frequency search radar that provides lateral coverage of up to 60 NM and vertical coverage of up to 40,000 feet altitude. The TPN-25 PAR is described in the next section. The RAPCON configuration of the TPN-19 consists of the GCA configuration with an OK-236 Operations Central. The central contains HF, VHF, and UHF radio communications, landline communications, and a microwave link. More modern than the MPN-14, the TPN-19 ASR and PAR radars are capable of autonomous operation. Only ten TPN-19 systems are available for worldwide deployment.

While not a tactical or mobile system, the GPN-24 (V) relocatable RAPCON is air-transportable, and as such, its potential use in the NAS warrants comment. The GRN-24 is a solid-state, modular facility with dual-channel, frequency diversity and a dual-beam antenna. The system is composed of a GPN-20 surveillance radar, an FPN-62 or GPN-22 precision radar and a TPX-42A secondary radar. The GSN-12 operations shelter contains ASR/PAR radar displays, remote controls, and communications controls for UHF and VHF radios, remoting terminals, and telephone and microwave communications. Designed to replace mobile

radars at overseas locations, the system has been utilized as a replacement system for Air Force fixed base ATC facilities undergoing major modification.

The Marine Air Traffic Control and Landing System (MATCALS) is an air-transportable, tactical air traffic control system that utilizes a distributed system architecture. The system is composed of a TSQ-107 surveillance radar and IFF/SIF, a TPN-22 precision radar, and a control and communications sub-system, the TSQ-131, which integrates all sensor data and functions as the operations center for MATCALS. The TSQ-107 ASR and beacon system detects and identifies airborne targets within a 240 nautical mile range. It consists of a UPS-1 surveillance radar with a TPX-42A(V)5 beacon system. Additionally, MATCALS possesses the necessary TACAN (TRN-44), UHF beacon (TRN-33), portable control tower (TSQ-120), instrument landing system (TPN-30), power supplies, and maintenance facilities to provide full ATC services at an expeditionary airfield. The TSQ-107 will be replaced with the TPS-73.

The TPS-73 is composed of an S-band Air Surveillance Radar, a mono-pulse Secondary Surveillance Radar, a Beacon Sub-System for IFF/SIF, two identical independent tracker units that automatically initiate and maintain target tracks, and a dual-channel data interface unit for interface with the control and communications sub-system. The radar utilizes a dual-beam receiving system, crystal-controlled frequency generation, multi-circular and linear polarization, and a solid state transmitter to improve target detection in all environments. The tracker is capable of processing 600 radar return/beacon reply codes within one second. The secondary radar uses dual channels to provide superior azimuth resolution and accuracy, with manual or automatic change-over. The TPS-73 system is undergoing operational field tests.

An understandable limitation of the current inventory of mobile and tactical surveillance systems is their incompatibility with the digital radar data format required for "end-state" NAS ASRs. The systems listed above were designed for battlefield ATC and airspace management, not NAS operation. However, next generation military surveillance radars presently under concept development, such as the Army's Air Traffic Navigation, Integration, and Coordination System (ATNAVICS) and the Air Force's New Mobile RAPCON (NMR) and Automated Tactical Aircraft Launch and Recovery System (ATALARS), include NAS interoperability as a system requirement. The Marine Corps plans to correct this limitation in the TPS-73 system.

The NMR program will field a new, rapidly-deployable system to provide tactical approach control services with a secondary mission of air defense support. The NMR consists of surveillance radar and operations center sub-systems. The 60 NM range of the primary surveillance radar will be augmented by the 120 NM range of the secondary surveillance radar that will interface with current and planned ATCRBS and aircraft transponders. Radar data digital processing will be interoperable with the NAS format. The NMR will employ multi-functional consoles, data processing and peripheral equipment, VHF and UHF radios with HAVE QUICK anti-jam capability, fiber optic landlines, and anti-radiation detection and electronic counter-counter measure (ECCM) capabilities. A modified version of the TPS-73 is being evaluated as a NMR candidate. When fielded, the NMR will also function as a temporary replacement system for fixed ATC facilities during periods of extended upgrade or transition.

2.1.2.1.2 Mobile Secondary Radar Systems

The TPX-42, the standard DoD ATCRBS as described previously, is also used in most tactical search radar systems operated by the military services. The Army uses two additional types of secondary radar sub-systems. The TPX-41 Interrogator Set is part of the FSQ-84. It operates as a complete aircraft identification system with both IFF and Selective Identification Feature (SIF). The SIF capability allows for selective identification of specific friendly aircraft. The TPX-44 is used in conjunction with the TPN-18A PAR as part of the TSQ-71B landing control central (refer to Section 2.1.2.2.2.1). The TPX-44 functions as an IFF/SIF system with remote control switching and provides a ground station function for the ATC system.

2.1.2.1.3 Tactical Automatic Radar Tracking Systems

The USMC MATCALS is the only tactical ATC system capable of automatic radar tracking. Emerging systems such as ATALARS, ATNAVICS, and NMR are planned to be automatic tracking systems.

2.1.2.2 Terminal Control and Landing Systems

Military tactical terminal systems are interoperable with the current NAS to the extent required for their utilization. Whether deployed temporarily in the NAS or at overseas locations, DoD mobile control towers can tap into local telephone systems and manually pass flight data between other military towers and the host nation/FAA ATC system. Mobile instrument landing systems provide precision approach guidance to suitably equipped aircraft regardless of service origin.

2.1.2.2.1 Mobile Control Towers

The TSW-7A is a transportable tower for controlling terminal air traffic at large, instrumented Army airfields. It is a three-position, self-contained unit that includes five UHF and four VHF ground/air multi-channel radios, two emergency frequency receivers (VHF and UHF), barometer, wind instruments, light guns, and supporting environmental control and power generation equipment. This mobile tower cab can be ground or air transported, and operated autonomously or as part of a terminal landing system. The Army has implemented a communications upgrade program to extend the system's service life into the 1990s. The TSW-7 is also the standard Air Force mobile control tower. The Air Force is modifying the consoles to incorporate emergency/crash alarms, voice recorders, NAVAID monitors, and the capability to interface by direct communications with other military and civil ATC facilities.

Smaller and more mobile than the TSW-7A, the Army TSQ-70A aircraft control central is a tactical tower used to provide visual ATC at smaller airfields. The two-position unit provides ATC, in-flight assistance, and ground control functions. Communications with aircraft are accomplished using VHF, UHF, and HF radios.

The TSQ-97 is a four-person facility deployed for the control of air traffic at Army landing zones where VFR control is required. The facility includes VHF-AM/FM and UHF-AM communications capabilities, meteorological equipment and related accessories associated with the VFR control of terminal

traffic. System instruments indicate wind speed and direction, pressure altitude, and real-time position information.

The Marine Corps TSQ-120 air traffic control central is a transportable tower facility that includes a communications shelter, an operations shelter (cab), a tower support structure, and support equipment. The air-conditioned communications shelter houses the UHF/VHF/HF radios and radio selector group, telephone and distribution sub-systems, recorders, an intercom, and equipment monitoring components. The tower cab is air-conditioned and contains three controller consoles, a power/ signal distribution system, visual signalling devices, and fire detection equipment. Aircraft operations are coordinated with remote facilities and agencies through the use of telephone, intercom, and crash radio networks.

2.1.2.2.2 Mobile Precision Landing Systems

In general, the wartime requirement for all-weather precision landing capabilities at deployed locations is provided by mobile or tactical precision radar systems. The ILS systems, which dominate as fixed precision landing aids, cannot meet tactical demands due to extensive site preparation and installation requirements. Like their fixed-base radar counterparts, tactical PAR units will be replaced by tactical microwave landing systems or automatic recovery and landing systems at the turn of the century.

2.1.2.2.2.1 Mobile Precision Approach Radar

Army precision approach capabilities consist of the PAR equipment incorporated in the FPN-40/TSQ-84 previously described and the TSQ-71B landing control central. The TSQ-71B is a truck-mounted tactical shelter with two controller positions and controls for radio and telephone communications. The system includes the solid-state TPN-18A precision approach radar. The TPX-44 is included to provide an IFF capability to a maximum range of 80 NM. Although the system's 1950s components have undergone numerous modifications, the TSQ-71B remains unreliable and outdated. ATNAVICS will replace the system in the mid-1990s.

Air Force mobile PARs include the MPN-14 and TPN-25. With over 30 years of service, the MPN-14 PAR is becoming increasingly difficult to maintain. Under the MPN-14K modification program, the old tube-type components in the PAR will be replaced with solid-state equipment. The newer TPN-25 is a solid-state precision radar that is capable of simultaneously tracking and controlling six aircraft to a range of 20 NM in a 20 degree azimuth and 14 degree elevation sector. Circular polarization and digital MTI provide good performance in all types of weather. The system contains a display console, VHF and UHF radio communications, landline communications, and a microwave terminal. The Air Force is replacing the target data processor and receiver processor in order to improve system reliability to over 98%. The TPN-25 can operate autonomously or as part of the TPN-19 Landing Control Central.

The most capable of the tactical PARs is the Marine Corps TPN-22 when it is used in conjunction with the AN/UYQ-34 display processor as part of MATCALS. The system is capable of tracking up to six aircraft on final approach while simultaneously searching its sector coverage. Through the use of Tactical Digital Information Link-C (TADIL-C), compatibly equipped aircraft can receive

fully automatic or semi-automatic control for either approach/departure flight path command or final approach commands.

2.1.2.2.2.2. Mobile Instrument Landing Systems

The Army and Air Force rely on mobile PARs to fulfill tactical precision landing requirements. The two current mobile instrument landing systems are the TRN-28 and TPN-30. The TRN-28 is a transportable Ka-band instrument landing system that is used by the Navy as a fixed base system. The TPN-30, also known as the Marine Remote Area Automatic Landing System (MRAALS), is a two person transportable, all-weather instrument landing system that transmits azimuth and elevation angle data to specifically-equipped aircraft. The airborne system translates the data and provides guidance information to the pilot. It can be set up in either collocated or split-site configurations. The collocated site uses one TPN-30 to provide azimuth, elevation, and range data for landing zones. The split-site for airfields uses two TPN-30s: one at the end of the runway which provides azimuth data; and one parallel to the runway, which provides elevation and range data.

To meet future DoD tactical precision approach requirements, the Air Force is developing the Mobile Microwave Landing System (MMLS). The tactical unit will be a modular, man-portable, and highly-mobile MLS system built to provide tactical precision instrument approach and landing capabilities down to ILS Cat-II (100 feet ceiling and 1/4 mile visibility) landing minima. Like the TPN-30, the MMLS will be used in collocated and split-site configurations. Almost 100 MMLS systems will be acquired by the military services for tactical use and for temporary replacement of inoperative fixed-base MLS systems.

2.1.2.3 Tactical Position/Navigation Systems

2.1.2.3.1 Tactical Position Systems

The tactical requirement for a precise, reliable, worldwide navigational system contributed to the development of the Global Positioning System (GPS). GPS is an emerging space-based radio positioning and navigation system that will provide position, velocity, and system time to suitably equipped aircraft, ships, land vehicles, and personnel (man packs). The DoD intends to use the GPS, along with an integrated INS, for primary navigation and for instrument approaches in the late 1990s.

The Position Location Reporting System (PLRS) is a joint Army and Marine Corps program designed to provide reliable data communications and position location services to tactical combat units. A PLRS system network consists of a mobile master station, a duplicate alternate master station, and up to 370 air- or ground-transportable user units. The PLRS operates on UHF frequencies and enables small units, vehicles, and aircraft to rapidly determine their positions as well as the positions of other PLRS-equipped units during periods of reduced visibility or in featureless terrain. PLRS readout devices display position and navigation information or limited free text messages. The position location accuracies of PLRS are 15 meters circular error probable (CEP) for ground users and 100 meter CEP for airborne users. An Enhanced PLRS (EPLRS), now under development, will provide automatic identification of EPLRS equipped forces.

The DoD's Joint Tactical Information Distribution System (JTIDS) also has relative position and navigation capabilities. Since it is primarily a communications system, JTIDS is discussed in Section 2.1.2.4.3.

2.1.2.3.2 Tactical Navigation Systems

The capabilities of radio-range emitting navigation stations are covered in Section 2.1.1.3. The two types of tactical NAVAIDs, TACANs and NDBs, and the Inertial Navigation System (INS) are identified in the following text, along with their unique system capabilities and limitations.

Mobile TACANs include the Air Force's TRN-26B, TRN-31, and TRN-41 systems, and the Marine Corps' TRN-44. The TRN-26 TACAN is a high-band, portable, dual system that can be reconfigured to satisfy varied operational requirements. By adding or deleting major components, the 100 NM range set can be converted from a single high-band to a dual all-band configuration. The latter configuration, designated the TRN-26B, incorporates optional shelter and supplemental all-band antenna components that enable it to be used as an en route/terminal NAVAID. It is often deployed in the NAS as a temporary replacement for inoperative fixed TACANs. The TRN-31 is the only transportable, high-power (3000 watts plus), and all-band TACAN in the Air Force inventory. However, the system is hard to maintain due to its age and difficult to deploy because of its size and power requirements. The Marine Corps' TRN-44 is a dual-channel, high-band, portable TACAN that has a 200 NM radius of coverage. It is used for both en route navigation and instrument approach guidance as part of the MATCALS.

The Army TRN-30 and Marine Corps TRN-33A are the current tactical NDBs. Army tactical ATC teams depend on the TRN-30 family of NDBs to provide a means of establishing en route and terminal navigation structures. Variations of the TRN-30 include long- and short-range beacons for tactical ATC. The Marine Corps' TRN-33A is a transportable, dual-channel navigational aid that provides UHF Automatic Direction Finding (ADF) equipped aircraft with bearing information and station identification within a 50 NM radius. It can also provide Automatic Terminal Information Services (ATIS). Like all radio transmitters, NDBs can be easily located and either destroyed or jammed by hostile forces. For this reason, the navigational capability provided by tactical NDBs will be fulfilled in the future by the GPS.

Airborne Inertial Navigation Systems (INS) provide aircraft position, acceleration, velocity, heading, attitude, and altitude data to other aircraft avionics systems, including flight instruments, radar, weapons delivery systems, and automatic flight controls. An INS unit typically consists of three gyros, three accelerometers, and computer processors. The two types of INS are the conventional mechanical gyroscopes and the Ring Laser Gyroscope (RLG). Of the two, RLGs are much more reliable, use less power, and require less pre-flight preparation. Both provide very accurate acceleration, heading, and attitude information, and are invulnerable to jamming. A disadvantage common to both types, however, is that their operational accuracy is dependent on the accuracy of its initial programming/ alignment and drift rate. Accuracy may drift considerably over time, depending upon the frequency and quality of position updates.

To improve INS accuracy and overall system integrity during wartime, DoD is combining INS and GPS into an integrated navigation system, thereby taking advantage of the strengths of each. The resulting system provides very accurate

navigation and attitude information and is invulnerable to the jamming that can disrupt an independent GPS system. Improved performance is accomplished by combining the GPS's positional accuracy with the INS's attitude capability, and continuously updating the INS with the GPS to remove drift errors. By having an updated inertial platform, the system can provide navigation during the short periods when a GPS signal may be jammed. The integrated INS/GPS navigation system will likely become the DoD standard after the GPS becomes operational.

2.1.2.4 Communications Systems

Mobile control tower and radar communications are usually accomplished using landline telephone systems integral to such facilities. Mobile ATC facilities interface with local telephone systems to manually pass flight data information between adjacent military and FAA or host nation ATC facilities. In general, this system of manual communications is all that is required to conduct ATC from mobile facilities since the transfer of radar data or automated flight progress data does not normally occur between mobile and fixed facilities.

In the area of radio communications, most service initiatives for mobile ATC facilities are concentrating on the combat requirement for secure, anti-jam, digital and voice communications capabilities.

2.1.2.4.1 Mobile Air Traffic Control Facility Communications

The communications radios and control equipment deployed as part of military mobile ATC tower and radar systems range from difficult-to-maintain, tube-type radios to modern, solid-state systems with secure and anti-jam capabilities. In general, the age, maintainability, and technological sophistication of military mobile ATC communications systems parallels that of the systems with which they are integrated.

Older facilities, such as the Army's TSQ-70A aircraft control central and TSQ-97 ATC facility and the Air Force's MPN-14 mobile RAPCON have been modernized to varying degrees but still contain older communications and control equipment. Some of the systems that are programmed to be replaced (i.e., mobile PARs by the MMLS, the Air Force's MPN-14 by the NMR, the Army's TSQ-71B by ATNAVICS, etc.) have been minimally modernized to extend their service lives while the newer systems are developed and fielded. Although the types of communications equipment in the older systems are functional, they reflect outdated 1960 to 1970 technology that lacks modern control/switching systems and interface terminals.

Mobile units, including the TSW-7A tower (Army/Air Force) and the TPN-19 mobile RAPCON (Air Force), are undergoing modifications to improve communications performance through the addition of new emergency/crash alarms, interfacility communications, consoles, amplifier and control modules, and VHF/UHF multichannel radios. The modernization programs will extend the utility of the systems through the 1990s. However, the need for secure, jam-free, voice and data communications will remain unfulfilled until newer systems are fielded.

2.1.2.4.2 Other

Several DoD joint programs are developing and fielding new tactical communications systems to meet the aforementioned requirement. The HAVE QUICK

program was initially designed to provide an short-term, jam-resistant, UHF voice communications capability to U.S. and NATO military forces. HAVE QUICK radios utilize frequency-hopping to counter hostile jamming. Some ATC facilities have been equipped with modified ARC-164 or GRC-171 radios to be compatible with aircraft using HAVE QUICK units. The follow-on HAVE QUICK II program is providing incremental changes to the existing radios by adding more frequencies, computer memory and software improvements, and equipment encoding capabilities. Future improvements are being developed to increase the frequency hop rate, power, and digital signal output of the system while retaining its interoperability.

A counterpart to HAVE QUICK, the Single Channel Ground and Airborne Radio System (SINCGARS) was designed to achieve DoD interoperability in an anti-jam mode in the VHF spectrum. SINCGARS is a secure, frequency hopping, single-channel VHF-FM radio used by all services. It is mission-flexible for voice or data, plain or cipher text, and secure remote operation. A family of eight radios used for various applications will replace existing radios, which include some ATC facility radios. The GRC-205 HAVE SYNC radio is part of the MATCALS system and will likely be incorporated in other military mobile facilities.

The Joint Tactical Information Display System (JTIDS) is a time division multiple access communication system that provides jam-resistant digital communication of data and voice for command and control, navigation, relative positioning, and identification functions. With an operating range between 300 and 500 NM, JTIDS is a highly-survivable system that permits tactical elements to track each other and select the information needed from the interoperating network. It is a secure, high-capacity, real-time system. In the JTIDS concept, one or more networks can be established over a battlefield simultaneously and a user can participate in several networks simultaneously. Five different types of JTIDS terminals are undergoing development for various host vehicles. Class 1 terminals are large terminals that are used in the AWACS and ground control centers. Class 2 terminals will be installed in several larger U.S. and NATO fighters, while a smaller version of the system is being assessed for use in other fighter aircraft. The Class 2M terminals are being designed for Army and Marine Corps command and control centers and shelters.

The consolidation of fixed and tactical ATC components described above into an operable ATC system depends upon the location and mission of the armed forces being supported and the availability and capabilities of the equipment. Also crucial to the utility of a specific ATC system are its interoperability with the host environment in which it will function. The following sections address the compatibility and interoperability of military ATC equipment with the NAS. While comments are included in reference to near-term developments, the focus of the discussion is upon the present NAS.

2.2 Compatibility and Interoperability

In spite of the equipment limitations described throughout the previous sections, the current DoD ATC system "works." This can be attributed to the fact that, regardless of the type of radar systems fielded, ATC services can be effectively performed when inter- and intra-facility communications are maintained and airspace delegations and procedures are clearly established. DoD Level Two and Three facilities at higher density installations (over 10,000 operations quarterly) are compatible with interfacing FAA systems to the extent necessary to fulfill their delegated ATC responsibilities. In addition, most

Level Three facilities (over 25,000 operations quarterly) are capable of performing automatic hand-offs with neighboring en route and terminal systems. Although ATC units at low-density military airfields use less sophisticated equipment, they communicate with the FAA through dedicated landlines and are sufficiently interfaced to perform their assigned functions.

The issue of longer-term systems interoperability hinges upon DoD's commitment to field new ATC systems comparable to those being developed under the FAA's NAS Plan modernization programs. The advanced technological and automation features incorporated in emerging FAA systems will compound existing compatibility problems. The DoD will be required to procure and install common equipment or significantly upgrade existing systems in order to become and remain interoperable.

The following sections address the issue of the compatibility and interoperability of military ATC systems with the NAS today, along with some observations regarding end-state NAS requirements. The discussion does not include the position/navigation equipment detailed in previous paragraphs because these systems are fully interoperable with the NAS (i.e., all NAVAIDS) or are irrelevant to the compatibility and interoperability of current military ATC systems (i.e., GPS, PLRS, and INS). Inter-service interoperability factors are also discussed.

2.2.1 The National Airspace System

The NAS consists of a standardized group of fixed ATC systems that provide air traffic services to aircraft operating in the U.S. According to the NAS Plan, there are over two hundred major terminal and en route facilities in the NAS today. Twenty ARTCCs and three offshore control centers make up the national en route structure. Their long-range ARSR-3 and -4 surveillance radars are linked through computers to military and civil long-range and ATC terminal radar facilities to provide national radar coverage. In addition, adjacent ARTCCs are interconnected through computers and dedicated landlines to automatically process radar and flight data. All twenty ARTCC's have upgraded their computers to the IBM 4341 host standard to provide expanded computing and memory capability. The offshore control centers use EARTS for radar processing. The ARTCCs and centers control IFR aircraft and provide traffic separation, traffic and weather advisory, and emergency assistance functions.

Over 180 major terminal approach control facilities employ ASR-5 through ASR-8 surveillance radars along with ARTS-II through ARTS-IIIA radar tracking systems. As stated earlier, comparable military facilities included in this group use ASR-7/8 and TPX-42 systems. While supplementing en route radar coverage, the military and FAA civil facilities exchange flight information with adjacent ATC facilities through interconnected ARTCC computers, control traffic in their terminal areas, and provide traffic separation, sequencing, and advisory assistance services.

2.2.2 Military Systems Interface to the NAS

As stated in the NAS System Requirements Specification (NASSRS), the FAA is required to accept the interface of military ATC systems. Section 3.2.10 of the NASSRS, Support of Military Operations, states:

"The NAS shall facilitate the continued operation of military air traffic control facilities. The NAS shall facilitate adequate and timely data exchange between FAA and DoD air traffic control facilities. The NAS shall facilitate the timely transition of military and civil aircraft to and from airfields served by military air traffic control facilities and the FAA en route/terminal environments. The NAS shall recognize, utilize, and interface with DoD air traffic control facilities in the provision of common services to both civil and military system users."

The requirement to integrate military ATC facilities prior to the evolution of the NAS Plan did not pose extraordinary problems for the FAA since the capabilities of both military and civil facilities were generally similar. Although interoperability between DoD and FAA ATC and airspace management system components is not necessarily an immediate imperative, the installation of new civil equipment and automation software will probably transform the interoperability issue into a system modernization problem. The following subsections describe current interoperability/compatibility issues by major ATC systems categories.

2.2.2.1 Fixed ATC Systems

Military fixed ATC units are compatible, and frequently interoperable, with contiguous facilities. Regarding control towers, the system and site-specific problems affecting daily operations, such as inadequate environmental sub-systems, structural and location problems, and "patchwork" communications controls, may reduce operational efficiency without affecting facility compatibility or interoperability. Even in those cases where equipment outages cause degraded facility status or operational restrictions, the affected ATCT may still interface with other air traffic elements, as long as basic communications and control capabilities exist. Interoperability may be lost, but not the compatibility which enables the facility to function as an integral part of the system. The same conclusion applies to military radar facilities. Military RAPCONs, ARACS, RATCFs, and GCAs "plug" into their respective host ARTCC in order to exchange data with the center and, in turn, with neighboring facilities. The interoperability of radar data processing is necessary for the automated radar tracking required to control high-density areas, but is not a prerequisite for facility operation. As long as military radar facilities can interface with the host ARTCC, compatibility with the NAS is maintained.

There are no NAS interoperability or compatibility problems associated with contemporary military precision landing systems. A controller can guide an aircraft to the runway served by his PAR. In addition, any suitably-equipped aircraft can fly an ILS approach to an ILS runway. The ACLS system, which is unique to a few Navy and Marine Corps air stations and to specifically-equipped aircraft, is redundant to on-station PAR/ILS systems that can be used by other military and civil users.

There is limited compatibility between current airspace management systems and FAA facilities. Throughout the NAS, the use of airspace set aside for unique military operations (i.e., SUA, air refueling tracks/anchors, etc.) is manually coordinated by the military scheduling organizations and submitted to the controlling ARTCCs. The airspace schedules are manually integrated within each ARTCC for flow control purposes and transmitted to other FAA facilities, such as bordering ARTCCs and Flight Service Stations (FSS). Military training routes are coordinated by the military schedulers with the tie-in FSSs,

who are responsible for further dissemination. The operating airspace management systems (e.g., RASS, FACSCHED, and MASMS) described in Section 2.1.1.5 are interoperable with the on-line using organizations for daily management activities and compatible with the FAA for schedule and utilization reporting. This functional relationship will remain until the national military (MAMS) and FAA (NAMFAC) systems are operational and interconnected with each other and with their respective reporting structures.

The requirement for compatible, but not necessarily interoperable systems will remain until the FAA requires comformance to end-state NAS equipment and performance standards. The mandate will force interoperability with advanced automation system (AAS) hardware and software, common display and communications equipment, and other automation requirements. To obtain future interoperability, the DoD intends to acquire common equipment through FAA procurement contracts.

2.2.2.2 Mobile ATC Systems

As described earlier, military mobile ATC radar and tower facilities are connected by telephone to the host nation or FAA system. This minimum compatibility is all that is presently required for deployed operations or for the short-term replacement of fixed facilities. Only one current mobile radar system will be interoperable with the end state NAS. The MATCALS TPS-73 has the capability to provide automatic handoffs to FAA facilities, provided an FAA interface sub-assembly is acquired to enable the system to "plug into" a host ARTCC/ACF. Other mobile radar systems, such as the MPN-14, TPN-19, TPN-40, and the MATCALS TSQ-107, provide primary radar with limited secondary radar capability, but no automatic radar tracking capability.

2.2.2.3 Communications Systems

Generally speaking, ATC radio communications systems are interoperable with aircraft radios, employing the twenty-series family of VHF/UHF radios described previously. The diversity in communications sub-systems (e.g., intercom, telephone, landlines, antennas, etc.) presents considerable problems for system standardization and maintainability, but not for interoperability.

With FDS/FDIO installed at most DoD fixed control towers and installations planned for other facilities, military flight plan information processing will be interoperable with the FAA through the 1990s. In the longer term, military ATCT planners must interface tower communications with the FAA's national Tower Communications System (TCS), a concept of modern voice communications switching and control systems that will be operating in civil control towers. It is designed to be operated in conjunction with the Tower Control Computer Complex (TCCC) or to operate independently in those towers not equipped with the TCCC. Though DoD towers are potential candidates for such systems, no procurement arrangements have been initiated.

2.2.3 Inter-Service Interoperability

2.2.3.1 Fixed Base

The linchpin to ATC equipment interoperability/compatibility in the NAS is the FAA ARTCC. As described in previous sections, adjacent DoD facilities often use dissimilar equipment. Because the facilities interface with each

other through individual connections with common ARTCCs, the present "operational impact" of non-interoperable equipment is negligible. Regardless of the type of equipment used, adjacent facilities can manually transfer aircraft control provided they have established airspace boundaries and landline communications. For example, a TPN-40/TSQ-84 radar, provided with only a TPX-41 limited data block, can be used to control traffic. Even if a facility were to lose secondary radar, a controller could normally continue to control traffic, albeit with more difficulty and at a lesser traffic capacity.

2.2.3.2 Mobile Facilities

Current DoD mobile radars are not required to have and, therefore, do not have direct data interface with the FAA. Mobile radar systems are frequently deployed within CONUS to serve as temporary replacements for fixed facilities undergoing maintenance or to support military exercises. In most cases, landline communications have been installed and aircraft identification is manually coordinated between the mobile facility and the host/adjacent ATC facility due to the lack of radar data processing capability in the mobile radar. During field training exercises, the responsible military command will attempt to operate mobile ATC facilities inside another DoD ATC facility's airspace in order to minimize coordination problems with the FAA. However, many exercises occur outside of airspace controlled by DoD fixed ATC facilities. In these situations, the mobile system must interface by landline with adjacent facilities and use mutually acceptable procedures and boundaries in order to execute air traffic control responsibilities.

2.2.4 Other Factors

The issue of the compatibility/interoperability of civil and military NAS components is recognized by most of the appropriate national policy and planning bodies. Several ongoing technical committees have been chartered to address the ramifications of international, inter-service, and intra-agency communications, navigation, and surveillance issues. They include:

- Federal Radionavigation Plan;
- Armaments and Avionics Planning Committee;
- Joint Radar Planning Group;
- Positioning/Navigation Working Group; and
- Future Air Navigation Systems Committee of the International Civil Aviation Organization.

DoD responsibilities for ATC and related NAS matters are assigned to the DoD Policy Board on Federal Aviation, and through the Policy Board to the Joint Program Coordinating Office (JPCO), the National Airspace System Defense Acquisition Council (NASDAC), and the National Airspace System Plan Requirements Office (NASPRO). Collectively, these organizational structures provide the management oversight necessary to ensure DoD/FAA interface for fixed air traffic control and airspace management systèms. By January 1989, both the FAA and the DoD created long-range planning committees to address the out-year planning and coordination associated with the development of advanced ATC concepts and systems.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Military ATC services are effectively executed when communications, airspace jurisdictions, and procedures are established. However, the position of sufficient compatibility today will change to one of restrictive non-interoperability by the turn of the century. In order to interface acceptably with end-state NAS systems, the DoD is jointly procuring common ATC equipment with the FAA and plans to develop comparable Area Control and Combined Radar Facilities. Assuming this occurs, the military services will gain enhanced automation features and achieve systems interoperability with the end-state NAS. The extent to which DoD is able to sustain the commitment to the acquisition of interoperable systems will probably be affected by fiscal year funding considerations. In late 1988, the DoD eliminated the FY 1990-92 funds approved for the initial development of NAS systems. With more severe budgetary constraints likely to occur, the joint purchase of ATC systems becomes more problematic.

If current and future DoD budgetary constraints cause extensive delays in ATC equipment procurement, the DoD will further delay military system modernization and face the prospect of providing almost one-quarter of the nation's terminal ATC services with equipment that is non-interoperable and minimally compatible with the end-state NAS. This could force the FAA to assume a greater degree of control over DoD facilities and assigned airspace, or cause Congress to direct DoD congruity through accelerated equipment acquisition. Expanded FAA operational control might adversely affect the conduct of military flight operations, while a congressional procurement edict could force DoD to rechannel funds vital to other weapons systems programs in a short-term, unplanned manner.

3.1 Flying Safety

The NAS is a safe and efficient environment for the conduct of military flying activities. The infrequent operational limitations that have been imposed on military ATC facilities due to compatibility problems have had a negligible effect on safety, since they have primarily affected mobile facilities functioning on a temporary basis, which has only impacted the flow of participating military aircraft. All military ATC facilities operate in accordance with established FAA and departmental procedures and standards (i.e., safety).

Aviation safety is a dominant factor in the NAS modernization effort. Federal action and funding dedicated to system safety enhancements will probably increase because public pressure and over-reaction to aviation incidents will not permit a degradation in aviation safety, either real or perceived. Future flying safety, in terms of air traffic control, will be enhanced by the integration of newer equipment and advanced automation programs. Capabilities such as conflict alert, Mode C Beacon Intruder, MSAW, and Automated En Route Air Traffic Control (AERA) will be required in ATC facilities to safely and expeditiously service the projected increase in air traffic activity.

3.2 Operational Effectiveness

The DoD ATC system is not as efficient as the civil system, due to the maintainability and interoperability of military systems. Budget constraints have caused system problems to be "band-aided" instead of eliminated through the

purchase of more reliable equipment and components. Though the current DoD ATC system functions effectively, it is not keeping pace with the evolving federal ATC system. With further cuts in defense spending anticipated, new equipment procurement may be delayed or redlined altogether. Military ATC may soon be unable to interface effectively with the FAA, and be forced to relinquish responsibilities that it can no longer perform to acceptable standards.

3.3 Air Force Mission Impact

The bottom line to the Air Force with respect to ATC systems compatibility or interoperability is no present mission impact. To date, the disruptions to military aviation activities have been caused by problems in planning, coordinating, and approving the airspace and procedures needed to safely conduct operations. The one certain, but difficult to quantify, mission impact is that DoD's failure to modernize ATC in conjunction with the FAA will result in a system unable to interface with the NAS. This will ultimately degrade mission accomplishment.

APPENDIX A

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APPENDIX B

GLOSSARY

ADVANCED AUTOMATION FUNCTIONS - The ACCC shall receive from other ACCCs trail plans, trajectory update information, and messages containing inputs to and/or outputs from advanced automation functions such as Flight Plan Conflict Probe. The messages shall include flight plan conflict and airspace conflict alerts and displays.

AERODROME - A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and movement of aircraft. Aerodromes may include airports, heliports, and other landing areas.

AIR NAVIGATION FACILITY - Any facility used in, available for use in, or designated for use in, aid of air navigation, including landing areas, lights, any apparatus or equipment for disseminating weather information, for signaling, for radio-directional finding, or for radio or other electrical communication, and any other structure or mechanism having a similar purpose for guiding or controlling flight in the air or the landing and take-off of aircraft.

AIRCRAFT - Device/s that are used or intended to be used for flight in the air; when used in air traffic control terminology may include the flight crew.

AUTOMATIC ALTITUDE REPORTING - That function of a transponder which responds to interrogations by transmitting the aircraft's altitude in 100-foot increments.

CONFLICT ALERT - A function of certain air traffic control automated systems designed to alert specialists to existing or pending situations recognized by the program parameters that require their immediate attention/action.

DISTANCE MEASURING EQUIPMENT/DME - Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid.

EN ROUTE - One of three phases of flight services (terminal, en route, oceanic). En route service is provided outside of terminal airspace and is exclusive of oceanic control.

EN ROUTE AIR TRAFFIC CONTROL SERVICES - Air traffic control service provided aircraft on IFR flight plans, generally by ARTCCs (ACF), when these aircraft are operating between departure and destination terminal areas. When equipment capabilities and controller workload permit, certain advisory/assistance services may be provided to VFR aircraft.

EN ROUTE MINIMUM SAFE ALTITUDE WARNING/E-MSAW - A function of the NAS Stage A en route computer that aids the controller by providing an alert when a tracked aircraft is below or predicted by the computer to go below a predetermined minimum IFR altitude.

FLIGHT PLAN - Specified information relating to the intended flight of an aircraft that is filed orally or in writing with an ATC facility.

FLIGHT SERVICE STATION/FSS - Air traffic facilities which provide pilot briefing, en route communications, and VFR search and rescue services; assist lost aircraft and aircraft in emergency situations; relay ATC clearances; originate Notices to Airmen; broadcast aviation weather and NAS information; receive and process IFR flight plans; and monitor NAVAIDS. In addition, at selected locations FSSs provide En Route Flight Advisor Service (Flight Watch), take weather observations, issue airport advisories, and advise Customs and Immigration of transborder flights.

HANDOFF - An action taken to transfer the control of an aircraft from one controller to another if the aircraft will enter the receiving controller's airspace and radio communications with the aircraft will be transferred.

IFR AIRCRAFT/IFR FLIGHT - An aircraft conducting flight in accordance with instrument flight rules.

IFR CONDITIONS - Weather conditions below the minimum for flight under visual flight rules.

INSTRUMENT FLIGHT RULES/IFR - Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate type of flight plan.

INDIRECT-ACCESS VOICE COMMUNICATIONS - Means whereby a specialist can establish voice communications with a designated position through multiple actions on one or more physical devices.

INSTRUMENT LANDING SYSTEM/ILS - A precision instrument approach system which normally consists of the following electronic components and visual aids:

1. Localizer
2. Glide Slope
3. Outer Marker
4. Middle Market
5. Approach Lights

INTERROGATOR - The ground-based surveillance beacon transmitter-receiver, which normally scans in synchronism with a primary radar, transmitting discrete radio signals which repetitiously request all transponders, on the mode being used, to reply. The replies received are mixed with the primary returns and displayed on the same plan position indicator. Also applied to the airborne element of the TACAN/DME system.

NAS STAGE A - The en route ATC system's radar, computers and computer programs, controller plan view displays (PVDs/radar scopes), input/output devices, and the related communications equipment which are integrated to form the heart of the automated IFR air traffic control system. This equipment performs Flight Data Processing (FDP) and Radar Data Processing (RDP). It interfaces with automated terminal systems and is used in the control of en route IFR aircraft.

NATIONAL AIRSPACE SYSTEM/NAS - The NAS as used herein describes the FAA facilities, hardware, and software that are a predominant part of the NAS infrastructure and the personnel who operate and maintain that equipment to provide services to the user.

NAVIGATIONAL AID/NAVAID - Any visual or electronic device, airborne or on the surface which provides point-to-point guidance information or position data to aircraft in flight. NAVAIDS (VOR, VORTAC, and TACAN) aids are classed according to their operational use. The three classes of NAVAIDS are:

T - Terminal
L - Low altitude
H - High altitude

ROUTE - A defined path, consisting of one or more courses in a horizontal plane, which aircraft traverse over the surface of the earth.

SPECIAL USE AIRSPACE - Airspace of defined dimensions wherein aerial activities must be contained because of their nature, and/or wherein air traffic control limitations may be imposed upon aircraft operations that are not part of the contained activities. Special use airspace includes prohibited areas, restricted areas, warning areas, military operations areas, controlled firing areas, and alert areas.

SURVEILLANCE - The detection, location, and tracking of aircraft within NAS airspace for the purposes of control, separation, and identification. Surveillance systems are electronic in nature; visual methods are purposely excluded. In the case of dependent surveillance, the aircraft provides all flight information. Surveillance systems are differentiated as independent, independent cooperative, and dependent:

1. Independent Surveillance - A system which requires no airborne compatible equipment

2. Independent Cooperative Surveillance - A system which requires airborne compatible equipment (e.g., ATCRBS, Mode S)

3. Dependent Surveillance - A system which requires input from navigation equipment aboard the aircraft either via a data link (e.g., LOFF) or via voice transmission (pilot reports)

TACTICAL AIR NAVIGATION/TACAN - An ultra-high frequency electronic rho-thea air navigation aid which provides suitably equipped aircraft a continuous indication of bearing and distance to the TACAN station.

TERMINAL AREA - A general term used to describe airspace in which approach control service or airport traffic control service is provided.

TERMINAL AREA FACILITY - A facility providing air traffic control service for arriving and departing IFR, VFR, Special VFR, Special IFR aircraft and, on occasion, en route aircraft.

TOWER/AIRPORT TRAFFIC CONTROL TOWER - A terminal facility that uses air-ground radio communications, visual signaling, and other devices to provide ATC services to aircraft operating in the vicinity of an airport or on the movement area. Authorizes aircraft to land or takeoff at the airport controlled by the tower or to transit the airport traffic area regardless of flight plan or weather conditions (IFR or VFR). A tower may also provide approach control services.

USER - The external individual or group that receive services from the NAS (e.g., Pilot, Air Carrier, General Aviation, Military, Law Enforcement Agencies).

VFR AIRCRAFT/VFR FLIGHT - An aircraft conducting flight in accordance with visual flight rules or operating on a Special VFR clearance.

VFR CONDITIONS - Weather conditions equal to or better than the minimum for flight under visual flight rules.

VISUAL FLIGHT RULES/VFR - Rules that govern the procedures for conducting flight under visual conditions. The term "VFR" is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, it is used by pilots and controllers to indicate type of flight plan.

VISUAL METEOROLOGICAL CONDITIONS/VMC - Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better the specified minima.

VORTAC/VHF OMNI-DIRECTIONAL RANGE/TACTICAL AIR NAVIGATION - A navigation aid providing VOR azimuth, TACAN azimuth, and TACAN distance measuring equipment (DME) at one site.

APPENDIX C

ACRONYMS/ABBREVIATIONS

ACRONYM	MEANING
AAS	Advanced Automation System
ACLS	Automatic Carrier Landing System
ACCC	Area Control Computer Complex
ACF	Area Control Facility
ADS	Automatic Dependent Surveillance
AERA	Automated En Route Air Traffic Control
AFSS	Automated Flight Service Station
ARAC	Army Radar Approach Control
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCBI	Air Traffic Control Beacon Interrogator
ATCCC	Air Traffic Control Command Center
ATCRBS	Air Traffic Control Radar Beacon System
ATCT	Air Traffic Control Tower
ATNAVICS	Air Traffic Navigation, Integration and Coordination System
BRITE	Bright Radar Indicator Tower Equipment
CA	Conflict Alert
CONUS	Continental, Contiguous, or Conterminous United States
DBRITE	Digital Bright Radar Indicator Tower Equipment
DoD	Department of Defense
EARTS	En Route Automated Radar Tracking System
EMSAW	En Route Minimum Safe Altitude Warning
FAA	Federal Aviation Administration
FACSFAC	Fleet Area Control and Surveillance Facility
FDEP	Flight Data Entry and Printout
FDIO	Flight Data Input/Output
FSS	Flight Service Station
GPS	Global Positioning System
HF	High Frequency

ICSS	Integrated Communications Switching System
ILS	Instrument Landing System
MAMS	Military Airspace Management System
MHz	Megahertz
MLS	Microwave Landing System
MMLS	Military Microwave Landing System
Mode C	Altitude Reporting Mode of Secondary Radar
Mode S	Discrete addressable Secondary Radar System with Data Link
MOA	Military Operation Area
MSAW	Minimum Safe Altitude Warning
NARACS	National Radio Communications System
NAS	National Airspace System
NASP	National Airspace System Plan
NAVAID	Navigational Aid
PAR	Precision Approach Radar
PIDP	Programmable Indicator Data Processor
RAPCON	Radar Approach Control
RATCF	Radar Air Traffic Control Facility (Navy)
RCF	Remote Communication Facility
TAAS	Terminal Advanced Automation System
TACAN	Tactical Aircraft Control and Navigation
TCAS	Traffic Alert and Collison Avoidance System
TCCC	Tower Control Computer Comples
TCS	Tower Communications System
TPX	Military Beacon System
TRACAB	Terminal Radar Approach Control in the Tower Cab
TRACON	Terminal Radar Approach Control Facility
UHF	Ultra High Frequency
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	Very High Frequency Omnidirectional Radio
VORTAC	Collocated VOR and TACAN

INTERAGENCY AGREEMENT A
DESIGNATING SELECTED APPROACH CONTROL JURISDICTIONS
to
MEMORANDUM OF AGREEMENT
Between
DEPARTMENT OF DEFENSE and FEDERAL AVIATION ADMINISTRATION
on
RADAR APPROACH CONTROLS IN THE NATIONAL AIRSPACE SYSTEM

ARTICLE - 1: AGREEMENT: In accordance with the MOA between the DOD and FAA on Radar Approach Controls in the National Airspace System, the FAA and DOD agree to the following radar ATC facility realignments. The many other locations where FAA currently provides approach control service for the military remain unchanged and are to be integrated into the ACF having airspace jurisdiction. The effective dates for transfer of jurisdiction shall be shown as mutually agreed in Interagency Agreement E (Transition Planning) to the basic MOA on Radar Approach Controls in the NAS.

ARTICLE - 2: OPERATIONAL CAPABILITIES: The FAA is engaged in an upgrade and modernization of the NAS. DOD NAS facilities providing approach control service in the NAS shall have certain capabilities which are now under development, over and above those now possessed in all locations. In addition to primary terminal radar (ASR), these specific capabilities are defined in the NAS System Level Specification, section 3.7.1.1. As a minimum, these capabilities are: 1) ground based Mode-S/Air Traffic Control Radar Beacon System (ATCRBS), 2) NAS data-link capabilities, 3) conflict alert function, 4) automatic handoff capabilities, 5) minimum safe altitude warning systems, 6) weather display capabilities, 7) conflict resolution advisory capability, 8) flight plan processing, and 9) the ability to receive/acknowledge traffic management system data and ATC mail. When these capabilities are required in FAA facilities, they shall also be required in DOD approach controls.

ARTICLE 3 - FUNDING AVAILABILITY

Implementation of this MOA is subject to the availability of FAA and DOD funding.

ARTICLE - 4: RADAR FACILITY ARCHITECTURE: The DOD and FAA agree to the following approach control realignments:

A. <u>APPROACH CONTROLS TRANSFERRED TO FAA FROM DOD</u>:

AIR FORCE BASES: Eaker AFB, AR (previously Blytheville AFB, AR); Dover AFB, DE; Grand Forks AFB, ND; Grissom AFB, IN; K.I. Sawyer AFB, MI; McGuire AFB, NJ; Minot AFB, ND; Patrick AFB, FL; Scott AFB, IL; Selfridge AFB, MI; Travis AFB, CA; Wurtsmith AFB, MI - all to be operated from the FAA ACF designated as the controlling facility.

NAVAL AIR STATIONS: Brunswick NAS, ME and Pt. Mugu NAS, CA - to be operated from the FAA designated ACFs.

B. APPROACH CONTROLS TRANSFERRED TO DOD FROM FAA:

Corpus Christi, TX - to be operated from a Navy facility in the Corpus Christi area.

Pensacola, FL;* Mobile, AL;* and Gulfport, MS * - to be operated by the NAVY in the Pensacola area.

NAF El Centro, CA, (now operated by Los Angeles ARTCC) - to be operated from MCAS Yuma, AZ.

Guam Combined Center Radar Approach Control (CERAP) - CERAP service to be provided from a DOD facility on Guam.

Reese AFB, TX - to be operated as a joint facility from Fort Worth ACF.

* Pending Completion of Gulf Coast Study

C. AIR FORCE BASES CONTROLLED BY USAF CONTROLLERS IN AN FAA ACF:

Loring AFB, ME and Pease AFB, NH - to be operated from Boston ACF.

Reese AFB, TX - to be operated by the Air Force from Fort Worth ACF.

Whiteman AFB, MO - to be operated from Kansas City ACF.

D. LOCATIONS OPERATED FROM DOD CONSOLIDATED RADAR FACILITIES (CRF):

Sheppard CRF: Altus AFB, OK; Sheppard AFB, TX; and Ft. Sill, OK.

NAS Corpus Christi CRF: Corpus Christi; NAS Corpus Christi; Chase; Kingsville (all TX).

NAS Pensacola ACF: Pensacola, FL*; Gulfport, MS*; Mobile, AL*; Tyndall AFB, FL*; Eglin AFB, FL (CRF)*; and Ft. Rucker, AL.*

Yuma CRF: NAF El Centro, CA; MCAS Yuma, AZ.

Cherry Point CRF: Cherry Point MCAS and New River MCAS.

* Pending Completion of Gulf Coast Study

E. DOD APPROACH CONTROL FACILITIES REMAINING UNCHANGED:

All DOD approach controls not listed above will be operated as facilities separate from ACFs or consolidated DOD facilities, and without change in approach control jurisdiction. This does not preclude normal airspace change through mutual negotiation and agreement. These facilities include:

ARMY: Ft. Campbell, KY; Ft. Hood, TX; Ft. Rucker, AL;* and Ft. Drum, NY.

NAVY and MARINE CORPS: Adak, AK; Kaneohe, HI; Beaufort MCAS, SC; Fallon, NV; Lemoore, CA; Key West, FL; Oceana, VA; Patuxent, MD; NAS Whidbey Island, WA; NAS Bermuda; and Roosevelt Roads, P.R.

AIR FORCE: Castle AFB, CA; Columbus AFB, MS; Cannon AFB, NM; Ellsworth AFB, SD; England AFB, LA; Holloman AFB, NM; Laughlin AFB, TX; Luke AFB, AZ; Moody AFB, GA; Mt Home AFB, ID; Nellis AFB, NV; Seymour-Johnson AFB, NC; Shemya, AK (GCA); Myrtle Beach AFB, SC; Shaw AFB, SC; Vance AFB, OK; Galena, AK;** King Salmon, AK;** and Vandenberg AFB, CA.

* Pending Completion of Gulf Coast Study
** Pending Completion of Alaska Study

F. EXCEPTIONS:

Guam: Staffing will be provided for the Guam CERAP by the DOD. The NAS equipment for this facility will be purchased and installed by the FAA. The maintenance, engineering and logistics support services for this facility will be provided by the FAA as provided for in Interagency Agreement C to the basic Memorandum.

Edwards AFB, CA: The staffing for this facility will be provided by the FAA on a reimbursed basis as provided for in a letter of agreement concerning this facility. The DOD shall reimburse the FAA on the basis of "fair share" as determined by the percentage of military and civilian air traffic support provided by this facility. Reimbursement shall include normal overhead operating expenses incurred by the FAA in direct support of this facility. The NAS equipment installed shall at least meet the requirements outlined in Article 2, but shall also take the mission requirements of Edwards AFB into account. The acquisition of NAS equipment, installation, logistics support, and upgrading of the physical facilities to support this new NAS equipment, will be accomplished by FAA. The DOD shall reimburse the FAA fully for these capital expenditures.

USAF Alaskan Facilities: The DOD approach controls at King Salmon and Galena shall be the subject of a joint cost-benefit study to determine the correct disposition of the facilities. The study shall consider whether the facilities should be upgraded or consolidated and whether the FAA or the DOD should serve as the controlling agency. The target for completion of this study and inclusion of these facilities as part of this Interagency Agreement is October 1, 1989.

Jacksonville, Florida area. The Jacksonville, FL airspace is unique due to the mix of aircraft, both civilian and military, and the close proximity of Navy and civilian airports. Currently, the Navy operates GCA services for NAS Jacksonville, NAS Cecil Field, and NAS Mayport from separate locations. The consolidation of services will be the subject of a joint FAA/DOD study to determine the delegated airspace. The results of this study shall be completed within 1 year of the signing of this Interagency Agreement and incorporated into this Memorandum.

The Gulf Coast Area: The DOD shall establish a Gulf Coast airspace management body on a permanent basis to provide a single point of contact and authority for airspace management and air traffic planning in the area. Included in this body shall be the approach control facilities supporting Mobile, AL; Gulfport, MS; Pensacola, FL; Tyndall AFB; Eglin AFB; and Ft. Rucker, AL. The DOD shall lead a joint study of this area, to be completed within 1 year of the signing of this Interagency Agreement, to determine whether a single consolidated CRF supporting all Navy, Army, and Air Force entities should be established.

Ground Controlled Approach Facilities, Tactical Facilities, and Military Towers: An addendum shall be made to this Interagency Agreement within 18 months of its signing, which describes the architecture, types of connectivity, and role of these facilities in the ACF era.

William H. Pollard
Associate Administrator
for Air Traffic

Frank J. Colson
Executive Director
DOD Policy Board on Federal Aviation

Edwin S. Harris, Jr.
Associate Administrator
for Airway Facilities

DATE: December 20, 1988